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JADS JT&E

End-to-End Test interim Report Phase 3

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Joint Test Force
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EXECUTIVE SUMMARY

1.0 Introduction

This summary serves as a stand-alone document, as well as part of this report. For that reason, the reader will find some duplication of verbiage and figures between the summary and the full report.

2.0 JADS Overview

The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) was chartered by the deputy director, Test, Systems Engineering and Evaluation (Test and Evaluation), Office of the Under Secretary of Defense (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation (ADS) technologies for support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). The program is Air Force led with Army and Navy participation. JADS Joint Test Force (JTF) manning currently includes 18 Air Force military, 4 Air Force civilians, 12 Army military, and 1 Navy civilian. Science Applications International Corporation and the Georgia Tech Research Institute provide contracted technical support. The program is currently scheduled to end in March 2000.

The JADS JTF is directly investigating ADS applications in three slices of the test and evaluation (T&E) spectrum: the System Integration Test (SIT) which explored ADS support of air-to-air missile testing; the End-to-End (ETE) Test which is investigating ADS support for command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test which is exploring ADS support for EW testing. The JTF is also chartered to observe or participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated test areas.

Phase 3, the transition phase of the ETE Test, is the subject of this summary report.

3.0 ETE Test Overview

The ETE Test is designed to evaluate the utility of ADS to support testing of C4ISR systems. The test uses the Joint Surveillance Target Attack Radar System (Joint STARS) as one component of a representative C4ISR system. The ETE Test also evaluates the capability of the JADS Test Control and Analysis Center (TCAC) to control a distributed test of this type and remotely monitor and analyze test results.

The ETE Test consists of four phases. Phase 1 developed or modified the components needed to develop the ADS test environment. Phase 2 used the ADS test environment to evaluate the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory environment.

Phase 3 transitioned portions of the architecture to the E-8C aircraft, ensured that the components functioned properly, and checked that the synthetic environment interacted properly with the aircraft and actual light ground station module (LGSM). Phase 4 will evaluate the ability to perform test and evaluation of the E-8C and LGSM in a synthetically enhanced live test environment.

4.0 Overview of ETE Test Phase 3

4.1 Purpose

Phase 3 provided an iterative step in determining the utility of ADS to the T&E of a C4ISR system. During this phase, portions of the architecture were transferred to the E-8C aircraft, the components were checked to make sure they functioned properly, and the synthetic environment was checked to make sure it interacted properly with the aircraft and the LGSM.

JADS Issue 1. What is the present utility of ADS, including DIS, for T&E?

> **JADS Objective 1-1**. Assess the validity of data from tests utilizing ADS, including DIS, during test execution.
>
> **JADS Objective 1-2**. Assess the benefits of using ADS, including DIS, in T&E. (This objective was not applicable to Phase 3 of the ETE Test.)

JADS Issue 2. What are the critical constraints, concerns, and methodologies when using ADS for T&E?

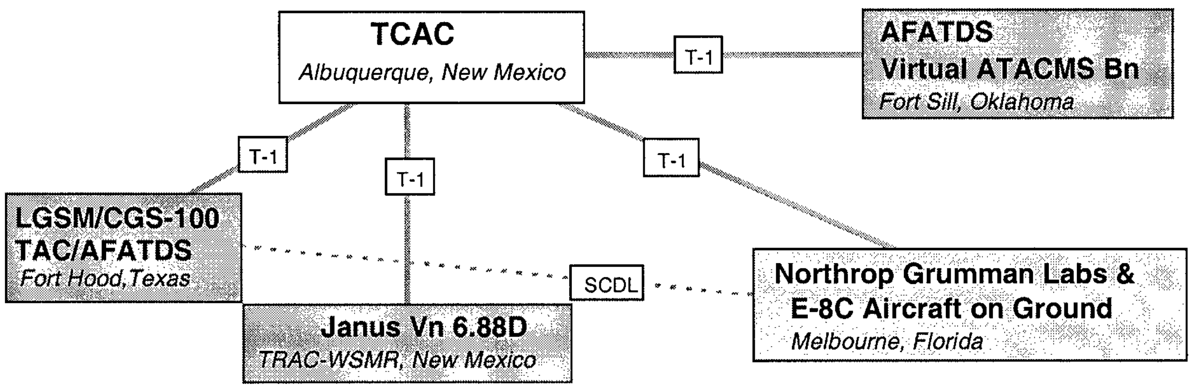
> **JADS Objective 2-1.** Assess the critical constraints and concerns in ADS performance for T&E. This objective was broken down into subobjectives.
>
>> **JADS Subobjective 2-1-1.** Assess player instrumentation and interface performance constraints and concerns. (This subobjective was not applicable to Phase 3 of the ETE Test.)
>>
>> **JADS Subobjective 2-1-2.** Assess network and communications performance constraints and concerns.
>>
>> **JADS Subobjective 2-1-3.** Assess the impact of ADS reliability, availability and maintainability on T&E.
>
> **JADS Objective 2-2.** Assess the critical constraints and concerns in ADS support systems for T&E. This objective was broken down into subobjectives.
>
>> **JADS Subobjective 2-2-1.** Assess the critical constraints and concerns regarding ADS data management and analysis systems.

JADS Subobjective 2-2-2. Assess the critical constraints and concerns regarding configuration management of ADS test assets. (This subobjective was not applicable to Phase 3 of the ETE Test.)

JADS Objective 2-3. Develop and assess methodologies associated with ADS for T&E. (This objective was not applicable to Phase 3 of the ETE Test.)

4.2 Approach

Figure ES-1 provides an overview of the Phase 3 ETE Test synthetic environment.

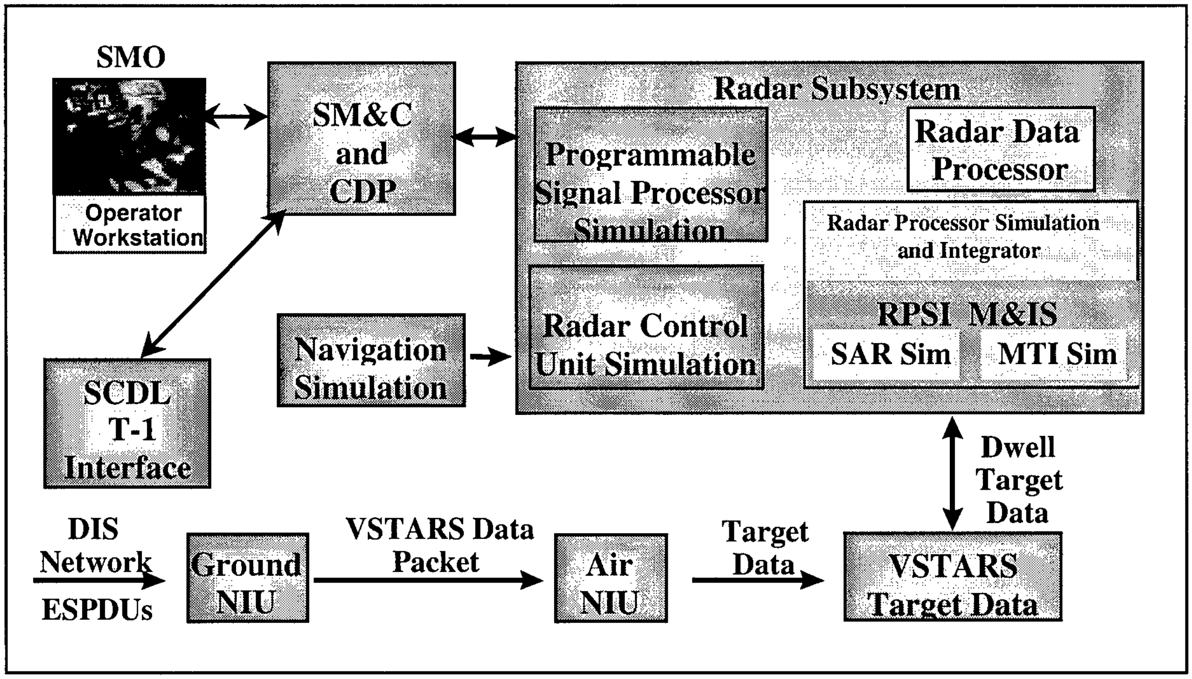


AFATDS = Advanced Field Artillery Tactical Data System
Bn = battalion
SCDL = surveillance control data link
TAC = target analysis cell
WSMR = White Sands Missile Range, New Mexico
ATACMS = Army Tactical Missile System
Janus = interactive, computer-based simulation of combat operations
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second
TRAC = U.S Army Training and Doctrine Command Analysis Center

Figure ES-1. ETE Test Phase 3 Synthetic Environment

The Test Control and Analysis Center in Albuquerque, New Mexico, provided test control.

The Joint STARS E-8C simulation, called the Virtual Surveillance Target Attack Radar System (VSTARS), represented the radar subsystem of the Joint STARS E-8C in a laboratory environment. It was composed of a distributed interactive simulation network interface unit (NIU), a radar processor simulator and integrator (RPSI) that contained the two real-time radar simulations with necessary databases, and various simulations of E-8C processes. Figure ES-2 provides more information on the VSTARS architecture.



CDP - central data processor
ESPDU = entity state protocol data unit
MTI = moving target indicator
SCDL = surveillance control data link
SMO - system management officer
DIS = distributed interactive simulation
M&IS - management and integration software
SAR = synthetic aperture radar
SM&C - system management and control
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second

Figure ES-2. VSTARS Architecture

The approach taken during the ETE Test Phase 3 was to migrate certain software components of VSTARS, specifically the air network interface unit (ANIU) and the radar processor simulator and integrator (RPSI), from the laboratory Alpha workstations to the primary mission equipment on the T3 E-8C aircraft. In addition, the ground network interface unit (GNIU) software would be separated from VSTARS and migrated to an Alpha workstation collocated with a satellite transceiver.

Once the migration was completed, each component was tested in isolation and then tested as a part of the complete environment. Specifically, the network to GNIU link was tested, and it was verified that the GNIU was issuing a VSTARS data packet for each protocol data unit (PDU) received. The GNIU to satellite transceiver to satellite transceiver to ANIU was also tested, and it was verified that VSTARS data packets were received and processed by the ANIU. Finally, the RPSI was tested, and it was verified that it processed the data and generated the appropriate radar reports. Once all components were shown to be working, the entire environment was tested using PDUs generated at the U.S. Army Training and Doctrine Command Analysis Center (TRAC), White Sands Missile Range (WSMR), sent to Northrop Grumman and then via satellite to the aircraft.

The last part of Phase 3 consisted of a series of system integration tests (SIT) conducted by the Joint STARS Joint Test Force and a complete verification and validation (V&V) of the RPSI.

The SITs, conducted using the T-3 aircraft and a medium ground station module (MGSM), were to determine if the software changes and additions made to the radar build in any way affected the performance of the radar and operator workstations. The V&V was to ensure that the ADS-enhanced radar system met the requirements and acceptability criteria established by the ETE Test team.

Fire support, provided by the Advanced Field Artillery Tactical Data System (AFATDS), and a LGSM were stationed at Fort Hood, Texas.

Communications among these command, control, communications, computers and intelligence (C4I) systems employed such doctrinally correct means as the CGS-100, a subsystem of the Compartmented All Source Analysis System Message Processing System (CAMPS), remote workstations, and AFATDS message traffic. The AFATDS messages were transmitted between the AFATDS located at Fort Hood and the AFATDS located at Fort Sill using actual tactical protocols rather than distributed interactive simulation (DIS) PDUs. Also, the surveillance control data link (SCDL) messages were transmitted between VSTARS and the LGSM using a dedicated link, a special-purpose interface, and the actual tactical protocols.

The Tactical Army Fire Support Model (TAFSM) simulation at Fort Sill modeled the Army Tactical Missile System (ATACMS) battalion (Bn) and sent the fire and detonate PDUs to the Janus 6.88D simulation. In turn, Janus modeled the engagement results and reflected the results in the synthetic environment.

5.0 ETE Test Phase 3 Results

5.1 Schedule

The overall ETE Test schedule is presented in Figure ES-3. Phase 3 testing proceeded as scheduled.

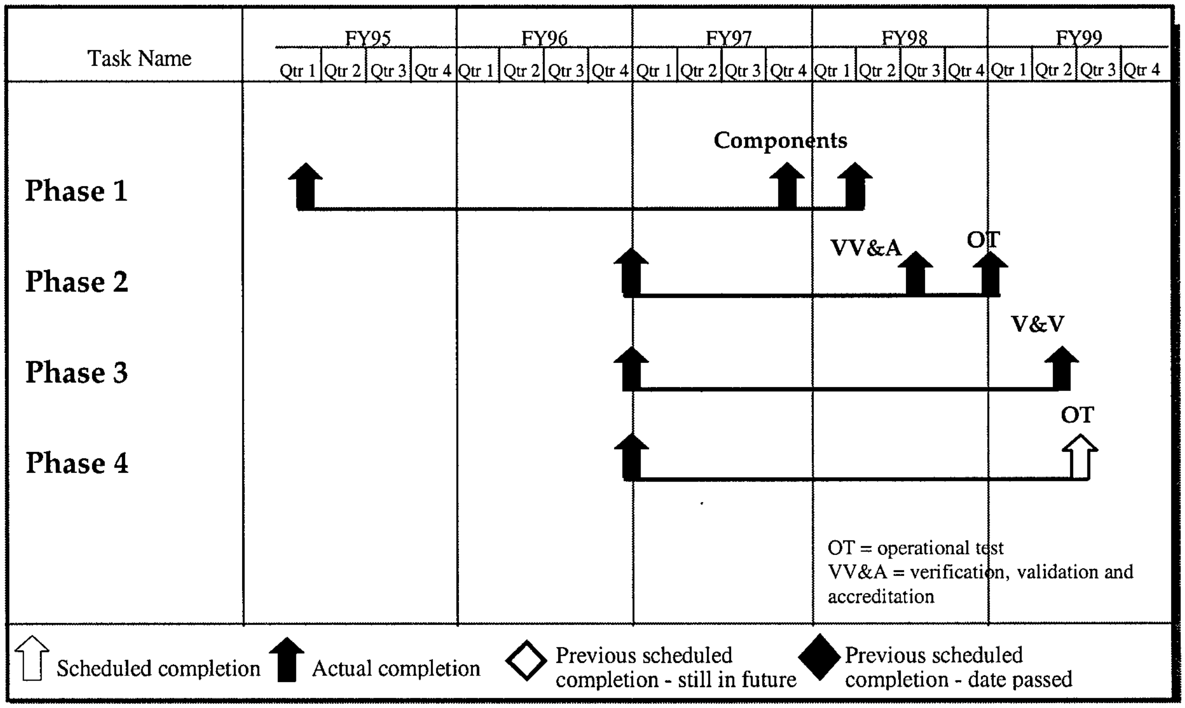


Figure ES-3. ETE Test Schedule

5.2 Fulfillment of Test Objectives

All ETE Test Phase 3 objectives were met. Phase 3 provided an iterative step in determining the utility of ADS to the T&E of a C4I system. This phase ensured that the RPSI functioned properly onboard the E-8C, and that the synthetic environment interacted correctly with the aircraft.

6.0 Lessons Learned

6.1 Technical

Testers should carefully plan the development of the simulations and links comprising their ADS environment. During test execution, they must ensure that the time sources are synchronized and continuously monitor PDU traffic. The distributed nature of ADS testing necessitates special equipment for network check-out and verification and requires strict configuration control of analysis tools and collected data.

6.2 Infrastructure and Process

ADS test planning should be detailed enough to encompass key requirements at the earliest possible stages, yet flexible enough to accommodate unexpected situations during test execution. A conservative development approach is recommended -- accomplish risk reduction activities before each ADS test and let each ADS test build on the success of earlier experiments. Successful test execution requires effective internode communication, test and resource control, and data management procedures.

7.0 Conclusions

7.1 Utility

A review of ETE testing to date indicates that an ADS environment can enhance C4ISR system DT&E and OT&E. In comparison with conventional tests, ADS allows testers to examine C4ISR systems under realistic conditions for longer periods of time, over far larger battlespaces, and at a much lower cost. This versatile technology can provide test environments that include large numbers of entities, entities operating under realistic but unsafe conditions, and joint and combined operations. ADS provides C4ISR system testers with greater flexibility in designing, executing, and analyzing their tests. During DT&E, ADS allows for more realistic compliance testing of C4ISR subsystems and efficient implementation of the test-fix-verify cycle for software development.

7.2 Technical

The ETE Test network was highly reliable during Phase 3 testing.

As expected, the Phase 3 testing at the Northrop Grumman node showed that all of the available satellite link bandwidth was required for data transmission, and that buffering was needed at times to handle periods of heavy scenario activity. Without buffering, the satellite link exhibited a normal latency of around two seconds. With buffering, the latency approached six seconds. Neither of these latencies was observable in the radar reports, indicating that the ETE Test synthetic environment is very tolerant of latencies in this range. However, ADS test planners need to consider these factors when testing other C4ISR systems involving satellite links.

7.3 Infrastructure

Based on cumulative ETE test experience, ADS testing reduces the need for large numbers of fielded personnel and vehicles, when compared with conventional testing. The ability to automatically collect and analyze test data also reduces the number of people required for setup, execution, and analysis. ADS test success relies on well-organized test control and data management procedures. Distributed testing requires sophisticated instrumentation, trained personnel to operate and maintain that equipment, and funds to support personnel and equipment at distant test nodes.

1.0 Introduction

1.1 Joint Advanced Distributed Simulation Overview

The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) was chartered by the deputy director, Test, Systems Engineering and Evaluation (Test and Evaluation), Office of the Under Secretary of Defense (OSD) (Acquisition and Technology) in October 1994 to investigate the utility of advanced distributed simulation (ADS) technologies for support of developmental test and evaluation (DT&E) and operational test and evaluation (OT&E). The program is Air Force led with Army and Navy participation. JADS Joint Test Force (JTF) manning currently includes 18 Air Force military, 4 Air Force civilians, 12 Army military, and 1 Navy civilian. Science Applications International Corporation (SAIC) and the Georgia Tech Research Institute provide contracted technical support. The program is currently scheduled to end in March 2000.

The JADS JT&E charter focuses on three issues: what is the present utility of ADS, including distributed interactive simulation (DIS), for test and evaluation (T&E); what are the critical constraints, concerns, and methodologies when using ADS for T&E; and what are the requirements that must be introduced into ADS systems if they are to support a more complete T&E capability in the future. From these, issues, objectives and measures have been developed to guide the evaluation.

The JADS JTF is directly investigating ADS applications in three slices of the T&E spectrum: the System Integration Test (SIT) which explored ADS support of air-to-air missile testing; the End-to-End (ETE) Test which investigated ADS support for command, control, communications, computers, and intelligence, surveillance and reconnaissance (C4ISR) testing; and the Electronic Warfare (EW) Test which is exploring ADS support for EW testing. Each test applied the JADS objectives and measures as appropriate to conduct its evaluation. The JTF is also chartered to observe or participate at a modest level in ADS activities sponsored and conducted by other agencies in an effort to broaden conclusions developed in the three dedicated test areas.

The JADS ETE Test is the subject of this report and is described in the next section; the following is a brief synopsis of the SIT and EW Test.

The SIT evaluated the utility of using ADS to support cost-effective testing of an integrated missile weapon/launch aircraft system in an operationally realistic scenario. The SIT also evaluated the capability of the JADS Test Control and Analysis Center (TCAC) to control a distributed test of this type and to remotely monitor and analyze test results. The SIT consisted of two phases each of which culminated in three flight missions. The missions simulated a single shooter aircraft launching an air-to-air missile against a single target aircraft. In the Linked Simulators Phase (LSP), the shooter, target, and missile were all represented by simulators. In the Live Fly Phase (LFP), the shooter and target were represented by live aircraft and the missile by a simulator.

The EW Test is evaluating the utility of ADS in a distributed EW environment. The first phase was open air testing to develop a performance baseline for two subsequent test phases. The first distributed test phase employed a linked architecture using Department of Defense's (DoD) high level architecture (HLA) which included a digital simulation model of the ALQ-131 self-protection jammer, threat simulation facilities, and constructive models which supported replication of the open air environment. In the second phase, an installed systems test facility was substituted for the digital model. In both distributed test architectures, system performance data were compared with live fly data for verification and validation (V&V).

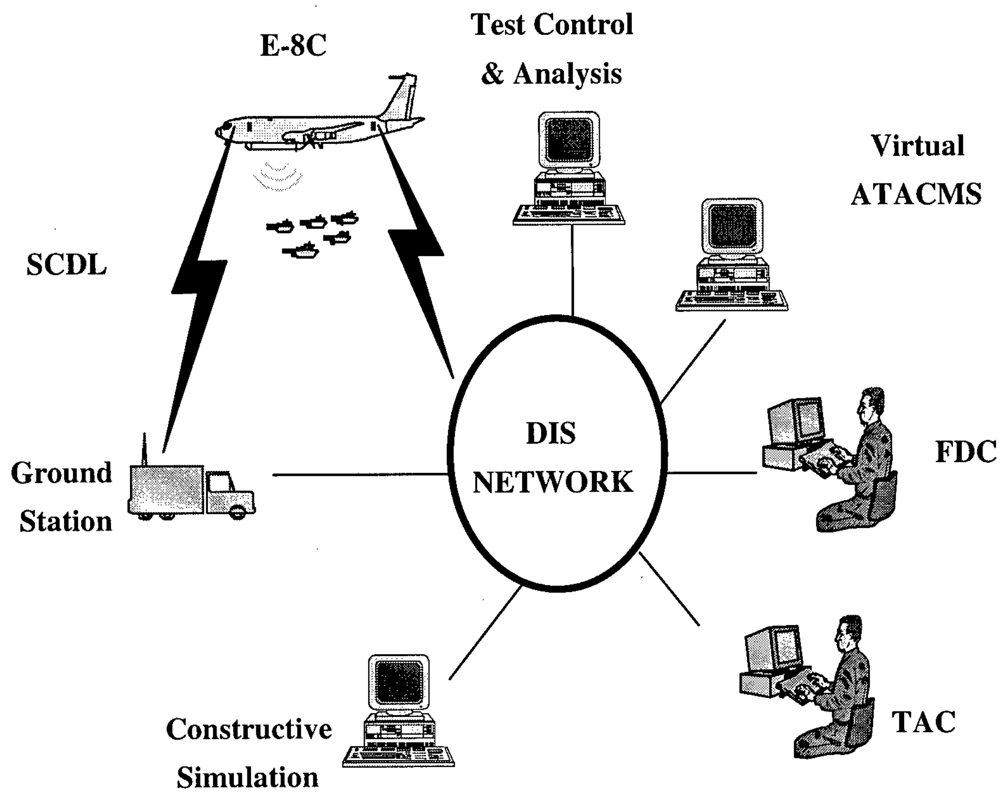
1.2 Test Overview

The ETE Test is designed to evaluate the utility of ADS to support testing of C4ISR systems. It will conduct its T&E utility evaluation in an ADS-enhanced test environment, using the Joint Surveillance Target Attack Radar System (Joint STARS) as one component of a representative C4ISR environment. The ETE Test will also evaluate the capability of the JADS TCAC to control a distributed test of this type and to remotely monitor and analyze test results.

The ETE Test is using distributed simulation to assemble an enhanced environment for testing C4ISR systems. The intent is to provide a complete, robust set of interfaces from sensor to weapon system, including the additional intermediate nodes that would be found in a tactical engagement. The test will trace a thread of the complete battlefield process from target detection to target assignment and engagement at corps level using ADS. It will allow the tester to evaluate the thread as a whole or the contribution of any of the parts individually and to evaluate what effects an operationally realistic environment has on the system under test.

The ETE Test is designed to add additional entities in a seamless manner to the battlefield seen by Joint STARS. In addition, adding some of the complementary suite of other command, control, communications, computers and intelligence (C4I) and weapon systems with which Joint STARS would interact will enable the test team to evaluate the utility of an ADS-enhanced test environment.

The test concept (Figure 1) used ADS to supplement the operational environment experienced by the E-8C and light ground station module (LGSM) operators. By mixing available live targets with targets generated by a constructive model, a battle array approximating the major systems present in a notional corps area of interest can be presented. By constructing a network with nodes representing appropriate C4I and weapon systems, a more robust cross section of players is available for interaction with the E-8C and LGSM operators.



ATACMS = Army Tactical Missile System FDC = fire direction center SCDL = surveillance control data link
TAC = target analysis cell

Figure 1. ETE Test Conceptual Model

Several components were required to create the ADS-enhanced operational environment used in the ETE Test. In addition to Joint STARS, the ETE Test required a validated simulation capable of generating entities representing the rear elements of a threat force. As discussed in Section 1.3.1, the ETE Test team selected the Janus simulation for this requirement. Also, simulations of the Joint STARS moving target indicator (MTI) radar and synthetic aperture radar (SAR) were needed to insert the simulated entities into the radar stream onboard the E-8C while it was flying a live mission. Other capabilities used to support the test include simulations or subsets of the Army's artillery command and control process and a simulation of the Army Tactical Missile System (ATACMS). Communications among these simulations are accomplished using such doctrinally correct means as the CGS-100, a subsystem of the Compartmented All Source Analysis System (ASAS) Message Processing System (CAMPS), remote workstations (RWSs), and Advanced Field Artillery Tactical Data System (AFATDS) message traffic.

The ETE Test consists of four phases. Phase 1 developed or modified the components that allowed the mix of live and simulated targets at an E-8C operator's console and an LGSM operator's console. Phase 2 evaluated the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory environment. Phase 3 transitioned portions of the architecture to the E-8C aircraft, ensured that the components functioned properly, and checked that the synthetic environment properly interacted with the aircraft and the actual LGSM. Phase 4 will evaluate the ability to perform test and evaluation of the E-8C and LGSM in a synthetically enhanced operational environment using typical operators.

1.3 Phase 1 Overview

During Phase 1, software and hardware needed to establish the ETE Test ADS environment were developed, modified, and integrated. In addition, Phases 2 through 4 were planned.

The ETE Test ADS environment components developed during Phase 1 included a constructive simulation to provide virtual targets, an E-8C simulation called the Virtual Surveillance Target Attack Radar System (VSTARS), an interface to allow surveillance control data link (SCDL) traffic to be exchanged between VSTARS and the ground station model (GSM), and an ADS network suitable for integration and testing.

More detailed information on Phase 1 can be found in the *End-to-End Interim Report, Phase 1,* August 1998, available at http://www.JADS.abq.com. (After 1 March 2000 refer requests to Headquarters Air Force Operational Test and Evaluation Center (HQ AFOTEC)/HO, 8500 Gibson Blvd SE, Kirtland Air Force Base, New Mexico 87117-5558, or SAIC Technical Library, 2001 North Beauregard St. Suite 80, Alexandria, Virginia 22311.)

1.3.1 Phase 1 Approach

The JADS ETE Test team developed requirements for a constructive simulation and then evaluated available simulations against these requirements. The Janus simulation, developed and managed by the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC), White Sands Missile Range (WSMR), New Mexico, was selected as the simulation best able to be modified to meet JADS' requirements. TRAC-WSMR expanded the Janus scenario driver into Janus 6.88D, a constructive simulation capable of supporting up to 10,000 individual entities with a distributed interactive simulation (DIS) interface to the ETE Test environment.

The JADS ETE Test team investigated existing simulations of Joint STARS and determined that none of them met the needed fidelity requirements. Based upon a JADS ETE Test concept, Northrop Grumman, the developer of the E-8C, created a laboratory emulation of the E-8C radar subsystem called the radar simulation processor and integrator (RPSI). VSTARS is a laboratory emulation of the E-8C aircraft that contains the RPSI and other aircraft components. VSTARS can receive entity state protocol data units (ESPDUs) from a DIS network and create virtual radar reports that are displayed on the Advanced Technology Work Station (ATWS) or an LGSM. The RPSI and the air network interface unit (ANIU) are the parts of VSTARS that are installed on the aircraft. The RPSI receives radar service requests (RSRs) from either an operator workstation (OWS) or a GSM and provides radar reports to the OWS and GSM.

Phase 1 also included the development of a near real-time emulation of the E-8C synthetic aperture radar (SAR). The JADS ETE Test team, through the Advanced Research Projects Agency (ARPA) War Breaker project, conducted a trade study of various existing simulations. The XPATCHES simulation, developed by Wright Laboratories and Loral Defense Systems (Goodyear, Arizona), was selected as the best starting point for the E-8C SAR emulation. Lockheed Martin Tactical Defense Systems (previously Loral Defense Systems), Goodyear, Arizona, developed the SAR emulation that represents the Joint STARS SAR. This emulation is referred to as the Advanced Radar Imaging Emulation System (ARIES) and is integrated into the RPSI.

The normal means of exchanging data among the E-8C and its associated LGSMs is through a line-of-sight data link that is called the surveillance control data link (SCDL). Internal to both the E-8C and the GSM, the data are handled as standard Ethernet packets and converted to SCDL format prior to transmission. They are also bridged over to a 1553 databus prior to being sent to the air data terminal (ADT) or the ground data terminal (GDT). Since the SCDL formatted data packets, prior to bridging over to the 1553 databus, can be sent via a T-1 line from point to point, it was determined that the data packets could be sent directly from VSTARS to the GSM's location. Once at the GSM's location, the data would be bridged over to the 1553 databus and input into the GSM as if they had been received by the GDT. Conversely, data originating at the GSM would leave the GSM on the 1553 databus and be bridged over to a protocol that could be sent via the T-1 line to VSTARS. Motorola developed the bridge between the LGSM and VSTARS. This interface unit links the T-1 with the internal 1553 databus of the LGSM and simulates some of the functions of the ground data terminal. This requires the LGSM operator to perform many of the normal linking process prior to receiving message traffic from VSTARS.

The Phase 1 network initially connected TRAC-WSMR with the JADS TCAC in Albuquerque, New Mexico, and was then extended from the TCAC to the Northrop Grumman laboratory facilities in Melbourne, Florida. Late in Phase 1, this network grew to include links from the TCAC to Fort Hood, Texas, and Fort Sill, Oklahoma, and a link between Northrop Grumman and Fort Hood.

1.3.2 Phase 1 Results

Phase 1 identified constraints associated with ADS testing. One key constraint was the ability of the DoD infrastructure to support ADS test and evaluation. A measure of this constraint is found in the amount of development required to establish a synthetic environment with which to conduct testing. Phase 1 provided insight onto the development required to support a test of this type. Phase 1 also demonstrated the application of a systems engineering methodology to identify the requirements for ADS components, evaluated the availability of ADS components, and modified or developed the components to meet the requirements.

During Phase 1 extensive testing was conducted to establish and verify the network configuration. Data management and analysis methods were also examined and the methods that were used during the subsequent phases of the test were developed.

1.4 Phase 2 Overview

Phase 2 of the ETE Test determined the utility of ADS to support DT&E and early OT&E of a C4ISR system in a laboratory-based environment.

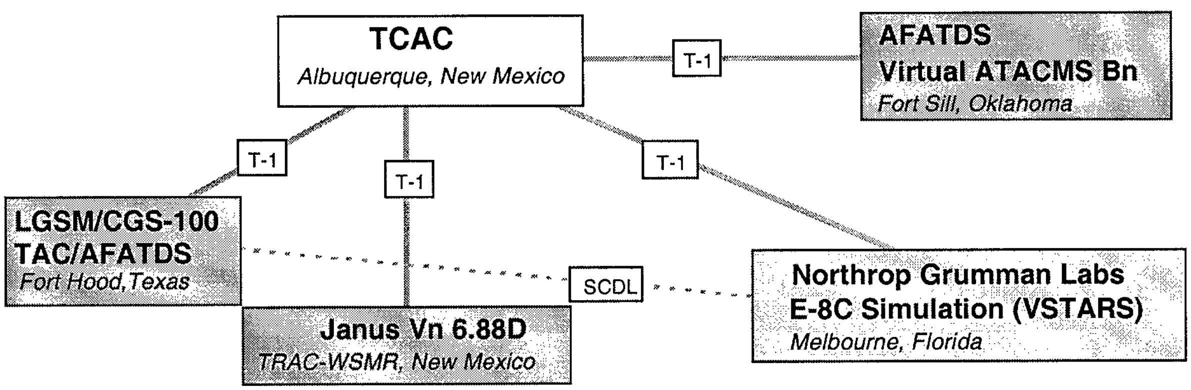
More detailed information on Phase 2 can be found in the *End-to-End Interim Report, Phase 2,* February 1999, available at http://www.JADS.abq.com. (After 1 March 2000 refer requests to HQ AFOTEC/HO, 8500 Gibson Blvd SE, Kirtland Air Force Base, New Mexico 87117-5558, or SAIC Technical Library, 2001 North Beauregard St. Suite 80, Alexandria, Virginia 22311.)

1.4.1 Phase 2 Approach

Several components were required to create the ADS-enhanced environment used in Phase 2. Figure 2 provides an overview of the Phase 2 synthetic environment.

The ETE Test used the Janus 6.88D simulation to generate the entities representing the elements in the rear of a threat force. Janus generated ESPDUs for the threat force which were transmitted to the E-8C simulation via the Test Control and Analysis Center (TCAC). TRAC-WSMR provided the Janus scenario feed.

The TCAC in Albuquerque, New Mexico, provided test control. The JADS Network and Engineering (N&E) team monitored the health of the ETE Test network and ensured that adequate data flowed in support of the test.



Bn = battalion
TAC = target analysis cell

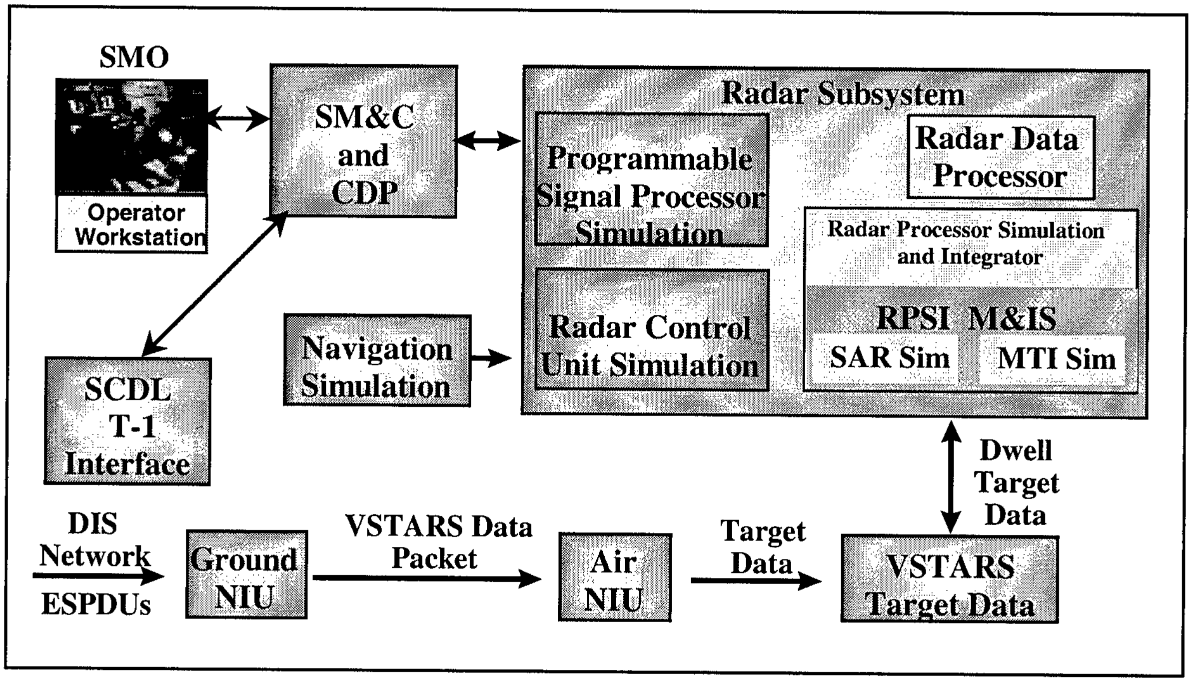
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second

Figure 2. ETE Test Phase 2 Synthetic Environment

The Joint STARS E-8C simulation, VSTARS, represents the Joint STARS E-8C in a laboratory environment. It is composed of a distributed interactive simulation network interface unit (NIU), an RPSI that contains the two real-time radar emulations with necessary databases, and various simulations of E-8C processes. Figure 3 provides more information on the VSTARS architecture. VSTARS was operated at the Northrop Grumman Surveillance and Battle Management Systems facility in Melbourne, Florida.

Fire support, provided by the AFATDS, and an LGSM were stationed at Fort Hood, Texas.

Communications among these C4I systems employed such doctrinally correct means as the CGS-100, a subsystem of the CAMPS, remote workstations, and AFATDS message traffic. The AFATDS messages were transmitted between the AFATDS located at Fort Hood and the AFATDS located at Fort Sill using actual tactical protocols rather than DIS PDUs. Also, the SCDL messages were transmitted between VSTARS and the LGSM using a dedicated link, a special-purpose interface, and the actual tactical protocols.



CDP - central data processor
SM&C - system management and control
M&IS - management and integration software
SMO - system management officer
T-1 = digital carrier used to transmit a formatted digital signal at 1.544 megabits per second

Figure 3. VSTARS Architecture

The Tactical Army Fire Support Model (TAFSM) simulation at Fort Sill modeled the ATACMS battalion and sent the fire and detonate PDUs to the Janus 6.88D simulation. In turn, Janus modeled the engagement results and reflected the results in the synthetic environment.

1.4.2 Phase 2 Results

All ETE Test Phase 2 objectives were met. The ETE Test ADS-enhanced environment was developed and tested. An extensive verification and validation was conducted of both the nodes and the overall environment, followed by accreditation of the environment for testing.

The ETE Test team determined that ADS testing can be beneficial for test planning, rehearsal, and execution, and can result in valid data being collected. During Phase 2, they also identified critical constraints, concerns, and methodologies associated with using ADS for test and evaluation. Finally, the ETE Test team utilized and assessed test control and data collection methodologies useful for ADS testing.

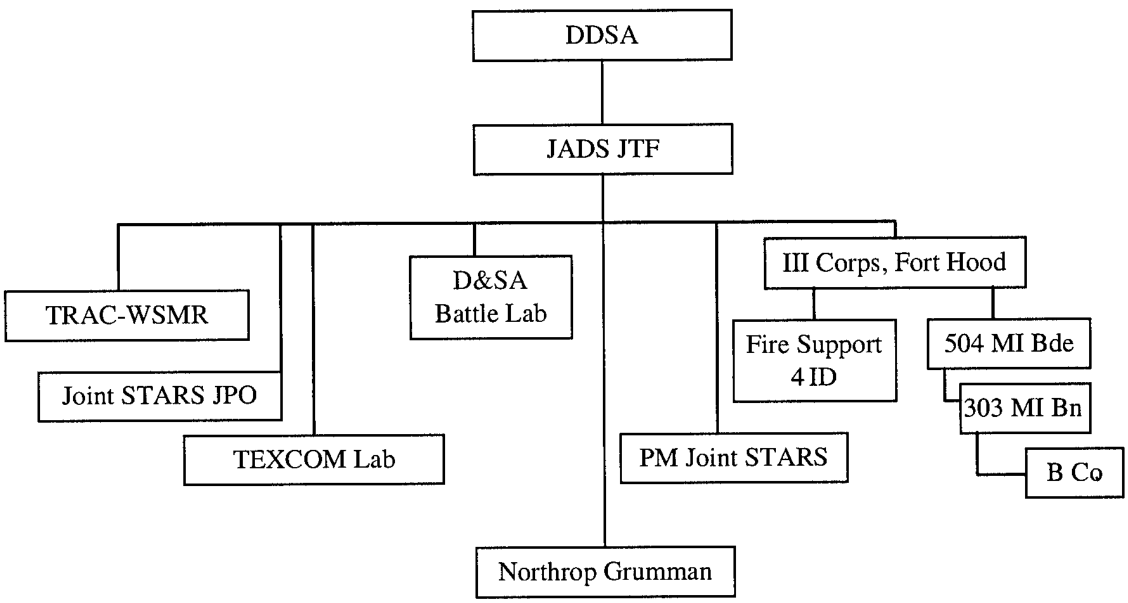
2.0 Phase 3 Overview

2.1 Phase 3 Purpose

Phase 3 provided an iterative step in determining the utility of ADS to the T&E of a C4I system. This phase ensured that the RPSI functioned properly onboard the E-8C, and that the synthetic environment interacted correctly with the aircraft.

2.2 Phase 3 Approach

Figure 4 shows the organizational structure for reporting and coordination during Phase 3 of the ETE Test.



Bde = brigade
D&SA = Depth and Simultaneous Attack
JPO = joint program office
TEXCOM = U.S. Army Test and Experimentation Command
Bn = battalion
DDSA = deputy director, System Assessment
MI = Military Intelligence
Co = company
ID = infantry division
PM = program manager

Figure 4. ETE Test Organizational Structure

During the ETE Test, the roles and responsibilities of these organizations are as follows.

DDSA

The deputy director, System Assessment (DDSA) in Washington, District of Columbia:

- Oversees the JADS Joint Test and Evaluation (JT&E)
- Approves JADS financial requirements
- Approves the program test plan (PTP)

- Oversees the analysis and reporting of test results

JADS JTF

The JADS JTF in Albuquerque, New Mexico:

- Conducts overall planning, execution, analysis, and reporting of the test
- Manages funding to accomplish the test
- Develops and evaluates JADS issues, objectives, measures, and related data elements
- Develops and integrates the components of the ETE Test ADS environment
- Establishes necessary communication links with test participants
- Operates the Test Control and Analysis Center during tests
- Works with other organizations in analyzing test data
- Reports interim and final results to OSD

TRAC-WSMR

TRAC-WSMR, New Mexico:

- Develops, tests, and documents Janus 6.88D (an expanded variant of Janus) for JADS
- Assists in integrating Janus 6.88D into the ETE Test ADS environment
- Assists in database conversions
- Assists in developing vignettes
- Assists in verification, validation, and accreditation (VV&A) activities
- Assists in ETE Test execution

TEXCOM Lab

The U.S. Army Test and Experimentation Command (TEXCOM) Lab at Fort Hood, Texas:

- Assists in scenario and vignette development
- Assists in ETE Test execution

D&SA Battle Lab

The Depth and Simultaneous Attack (D&SA) Battle Lab at Fort Sill, Oklahoma:

- Provides and operates the TAFSM and AFATDS
- Assists in the integration of the ETE Test ADS environment
- Assists in VV&A activities and ETE Test execution

U.S. Army III Corps

III Corps Headquarters at Fort Hood, Texas:

- B Company (Co), 303d Military Intelligence (MI) Battalion (Bn), 504 MI Brigade (Bde) supports the conduct of ETE Test events with LGSM(s) and a target analysis cell (TAC) and assists in the integration of the ETE Test ADS environment
- 504 MI Bde provides a test environment for the ETE Test
- Fire Support 4th Infantry Division (ID) provides an AFATDS and personnel to support the ETE Test

Joint STARS Joint Program Office (JPO)

Joint STARS JPO, Hanscom Air Force Base (AFB), Massachusetts, provides access to the Joint STARS JTF and Northrop Grumman.

The Joint STARS JTF of the Joint STARS JPO in Melbourne, Florida:

- Supports conduct of testing in all phases
- Analyzes Joint STARS test results and provides evaluations according to JADS objectives
- Assists in VV&A activities

Northrop Grumman Aerospace Corporation

Northrop Grumman, Electronics and Systems Integration Division in Melbourne, Florida:

- Designed, developed and integrated the RPSI
- Developed the VSTARS
- Conducts and assists in verification and validation activities
- Assists in E-8C mission planning
- Operates VSTARS during ETE Test phases

Contracting with Northrop Grumman is conducted through Rome Laboratory in New York.

2.3 Test Objectives

The JADS issues, test objectives, and subobjectives for Phase 3 are described below. Each subobjective in turn encompassed one or more test measures. In Section 4 these issues, objectives, subobjectives, and test measures are discussed in terms of their intent, the associated data collection methodology, and operational test results.

JADS Issue 1. What is the present utility of ADS, including DIS, for T&E?

JADS Objective 1-1. Assess the validity of data from tests utilizing ADS, including DIS, during test execution.

JADS Objective 1-2. Assess the benefits of using ADS, including DIS, in T&E. (This objective was not applicable to Phase 3 of the ETE Test.)

JADS Issue 2. What are the critical constraints, concerns, and methodologies when using ADS for T&E?

JADS Objective 2-1. Assess the critical constraints and concerns in ADS performance for T&E. This objective was broken down into subobjectives.

JADS Subobjective 2-1-1. Assess player instrumentation and interface performance constraints and concerns. (This subobjective was not applicable to ETE Test Phase 3.)

JADS Subobjective 2-1-2. Assess network and communications performance constraints and concerns.

JADS Subobjective 2-1-3. Assess the impact of ADS reliability, availability and maintainability on T&E.

JADS Objective 2-2. Assess the critical constraints and concerns in ADS support systems for T&E. This objective was broken down into subobjectives.

JADS Subobjective 2-2-1. Assess the critical constraints and concerns regarding ADS data management and analysis systems.

JADS Subobjective 2-2-2. Assess the critical constraints and concerns regarding configuration managment of ADS test assets. (This subobjective was not applicable to Phase 3 of the ETE Test.)

JADS Objective 2-3. Develop and assess methodologies associated with ADS for T&E. (This objective was not applicable to Phase 3 of the ETE Test.)

2.4 Phase 3 Methodology

2.4.1 Tactical Vignettes

The ETE Test Phase 3 tactical vignettes were a subset of the same vignettes used during Phase 2; Northrop Grumman used internal tapes from the Phase 2 test and direct connections to the ETE Test network.

The tactical vignettes for the ETE Test activities are unclassified. The ETE Test team used an enhanced TRADOC-approved, 54-hour corps battlefield simulation (CBS) scenario replicating an Iraqi corps rear area of operations in Iraq. Five tactical vignettes were created in Janus 6.88D;

Table 1 provides a description of each vignette. The following targets are present in the 150x150 kilometer (km) Southwest Asia (SWA) terrain box: air defense artillery (ADA) sites, command and control sites, lines of communications (convoys), logistics bases, and concentrations of armor and artillery units.

Table 1. Vignettes Used During ETE Testing

Vignette	Description	Number of Entities
1	Prehostility phase	9,897
2	Preemptive strikes	9,757
3	Hammurabi Division logistical operations	9,904
4	Commitment of the Hammurabi Division	9,781
5	General headquarters (GHQ) depots to corps and divisional logistical operations	9,950

2.4.2 Test Configuration

2.4.2.1 Phase 3 Synthetic Environment

ETE Test Phase 3 migrated certain software components of VSTARS, specifically the ANIU and the RPSI from the laboratory Alpha workstations to the primary mission equipment on the T3 E-8C aircraft. In addition, the GNIU software was separated from VSTARS and migrated to an Alpha workstation collocated with a satellite transceiver.

Once the migration was completed, each component was tested in isolation and then tested as a part of the complete environment. Specifically, the network to GNIU link was tested verifying that the GNIU was issuing a VSTARS data packet for each PDU received. The GNIU to satellite transceiver to satellite transceiver to ANIU was also tested verifying that VSTARS data packets were received. Finally, the ANIU and RPSI were tested using primary mission equipment in the laboratory verifying that they processed the data and generated the appropriate radar reports. Once all components were shown to be working, the software was moved to the aircraft. The entire environment was then tested using PDUs generated at TRAC-WSMR sent to Northrop Grumman and then via satellite to the aircraft.

2.4.2.2 Phase 3 Testing at the Northrop Grumman Node

Phase 3 testing at the Northrop Grumman node was conducted in four steps culminating with the transition of the ANIU and RPSI to the test aircraft. Following this transition, a series of system integration tests (SIT) were conducted by the Joint STARS Joint Test Force, and a complete V&V of the RPSI was conducted by Northrop Grumman with ETE Test V&V team oversight.

The SITs, conducted using the T3 aircraft and a medium ground station module (MGSM), determined if the software changes and additions made to the radar build in any way affected the performance of the radar and operator workstations. The V&V test ensured that the ADS enhanced radar system met the requirements and acceptability criteria established by the ETE Test team.

The Phase 3 test activities are further discussed in section 4.1 of this report.

2.5 Phase 3 Schedule

Figure 5 provides a schedule of the top-level tasks for Phase 3 of the ETE Test.

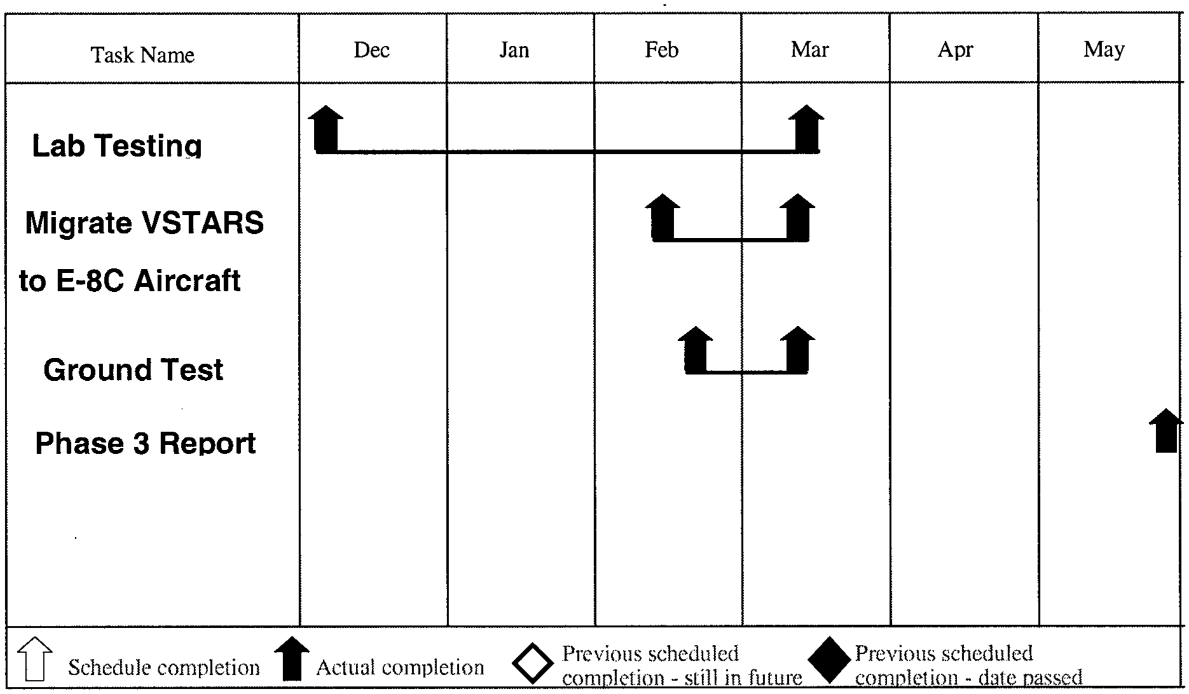


Figure 5. ETE Test Schedule

2.6 Phase 3 Costs

This report does not describe the costs of the ETE Test Phase 3. Rather, the report on Phase 4 will include a work breakdown structure covering the costs of all four phases of the ETE Test. The Phase 4 report will be published in summer 1999.

3.0 Phase 3 Execution Results

3.1 25-26 February 1999 and 10-12 March 1999 Testing

Phase 3 testing took place from 25-26 February 1999 and 10-12 March 1999. Section 4 discusses the specific measures addressed during this test and the data collected in support of those measures.

3.2 13 March 1999 Testing

Additional testing took place at the Northrop Grumman node on 13 March 1999. This testing had two objectives.

- Allow the Joint STARS JTF to perform the formal system integration tests (SITs) of the Joint STARS aircraft with the JDS 07_006+ software build in operation. The SITs are designed to verify the critical functionality of the Joint STARS system prior to flight testing.

- Conduct formal V&V testing of the JDS 07_006+ software onboard the aircraft.

The testing was conducted over a 12-hour period on 13 March 1999. The testing used recorded Janus vignettes played from equipment located in the Northrop Grumman lab, then broadcast via a satellite communications (SATCOM) link to the aircraft located on the tarmac. A MGSM located at the Joint STARS JTF facility was used to verify SCDL linking functions with the aircraft.

All of the formal testing conducted by the Joint STARS JTF was completed successfully with only minor discrepancies noted. In addition, the V&V was conducted at the same time. The results of these tests are further discussed in section 4.1.1 of this report.

4.0 Analysis of Test Objectives

During Phase 3 of the ETE Test, JADS analysts collected information to address the issues, objectives, and test measures as outlined in the JADS Program Test Plan (PTP) and the ETE Test Data Management and Analysis Plan (DMAP). Only those subobjectives and measures evaluated using Phase 3 results are discussed.

4.1 JADS Issue 1. What is the present utility of ADS, including DIS, for T&E?

4.1.1 JADS Objective 1-1. Assess the validity of data from tests utilizing ADS, including DIS, during test execution.

JADS Measure 1-1-0-1. Degree to which ADS provides valid system under test (SUT) data.

JADS Measure 1-1-0-2. Percentage of ADS data which are valid (data supporting test measures which are timely, accurate, reliable, and otherwise faithfully represent real-world systems data).

These two test questions gauge the ability of an ADS environment to provide valid data for the C4ISR SUT. The first measure addresses the validity of the SUT output data which forms the data elements for evaluating SUT measures. The second measure provides an assessment of the input data provided to the SUT by the ADS environment.

These measures were addressed during Phase 3 by implementation of the Phase 3 V&V Plan. The V&V approach focused on verifying that the changes made during Phase 3 were compatible with the ETE Test synthetic environment (SE). These changes included the following:

- The movement of the ANIU and the RPSI from the laboratory Alpha workstations to the primary mission equipment on the T3 E-8C aircraft.
- The migration of the GNIU software from VSTARS to an Alpha workstation collocated with a satellite transceiver.
- The linking of the GNIU and the ANIU via satellite communications (SATCOM).
- The replacement of the T-1 SCDL with the actual SUT SCDL.

These actions, in effect, replaced VSTARS with an ADS-enhanced E-8C aircraft within the ETE Test SE. The remainder of the SE was unaffected by the change because all inputs, outputs, and interactions were unchanged. As a result, all of the V&V findings reported upon in the *End-To-End Interim Report, Phase 2* still apply and were not repeated.

Phase 3 integration testing at the Northrop Grumman node was conducted in four steps culminating with the transition of the ANIU and RPSI to the test aircraft. Following this transition, a series of SITs were conducted by the Joint STARS JTF, and a complete V&V of the RPSI was conducted by Northrop Grumman with ETE Test V&V team oversight. These steps are detailed below along with verification results.

Step 1: Laboratory Test of the Isolated GNIU

As stated above, the GNIU software component of VSTARS was modified to work as an isolated software component on an Alpha workstation. Once this was complete, an abbreviated synthetic environment was established to verify that the GNIU could receive DIS ESPDUs and issue corresponding a VSTARS data packet (VDP) for each PDU received. Figure 6 describes the configuration for this step.

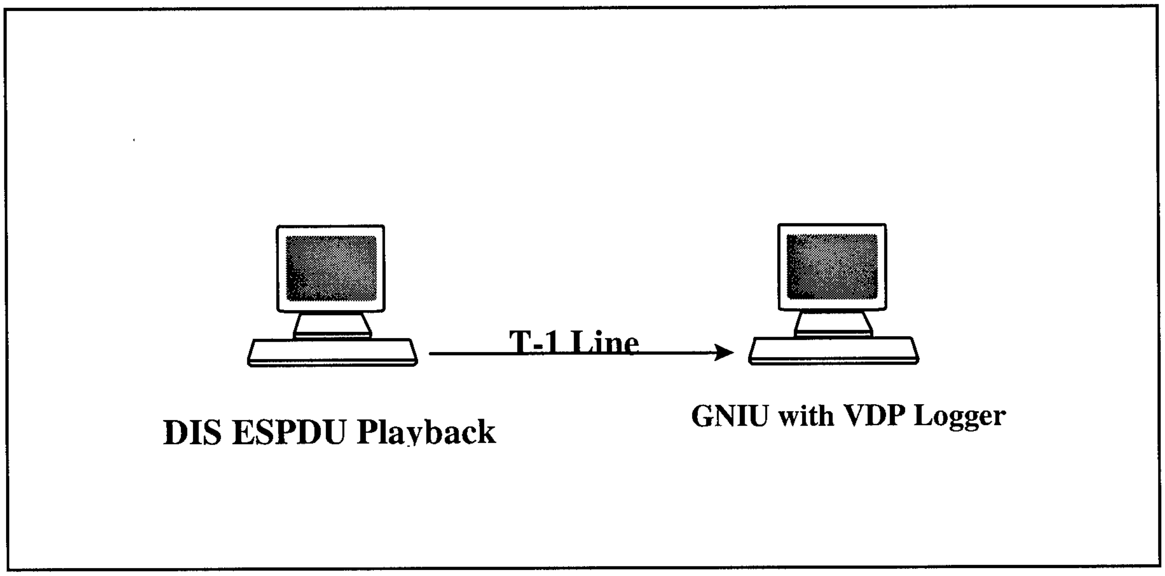


Figure 6. GNIU Test Synthetic Environment

In this environment, ESPDUs that were originally generated from a Janus 6.88D scenario were played back using a Silicon Graphics, Inc. (SGI) JADS player. These ESPDUs were broadcast over a T-1 communications link to the GNIU. Upon receipt of the ESPDUs, the GNIU processed the PDUs and issued correctly formatted VDPs.

Step 2: Laboratory Test of the GNIU to ANIU Satellite Link

Following the testing of the GNIU, the next step was to test the GNIU to satellite transceiver to satellite transceiver to ANIU link. This was accomplished in several stages starting with the connection of the satellite transceivers in the lab using a null modem and culminating with the use of a communications satellite to transmit VDPs from one site to another site. Figure 7 describes the final configuration for this step. In addition to developing and testing the necessary software required for the use of the satellite transceivers, this step was also used to develop the necessary test tools needed to measure the performance of the GNIU to ANIU satellite link.

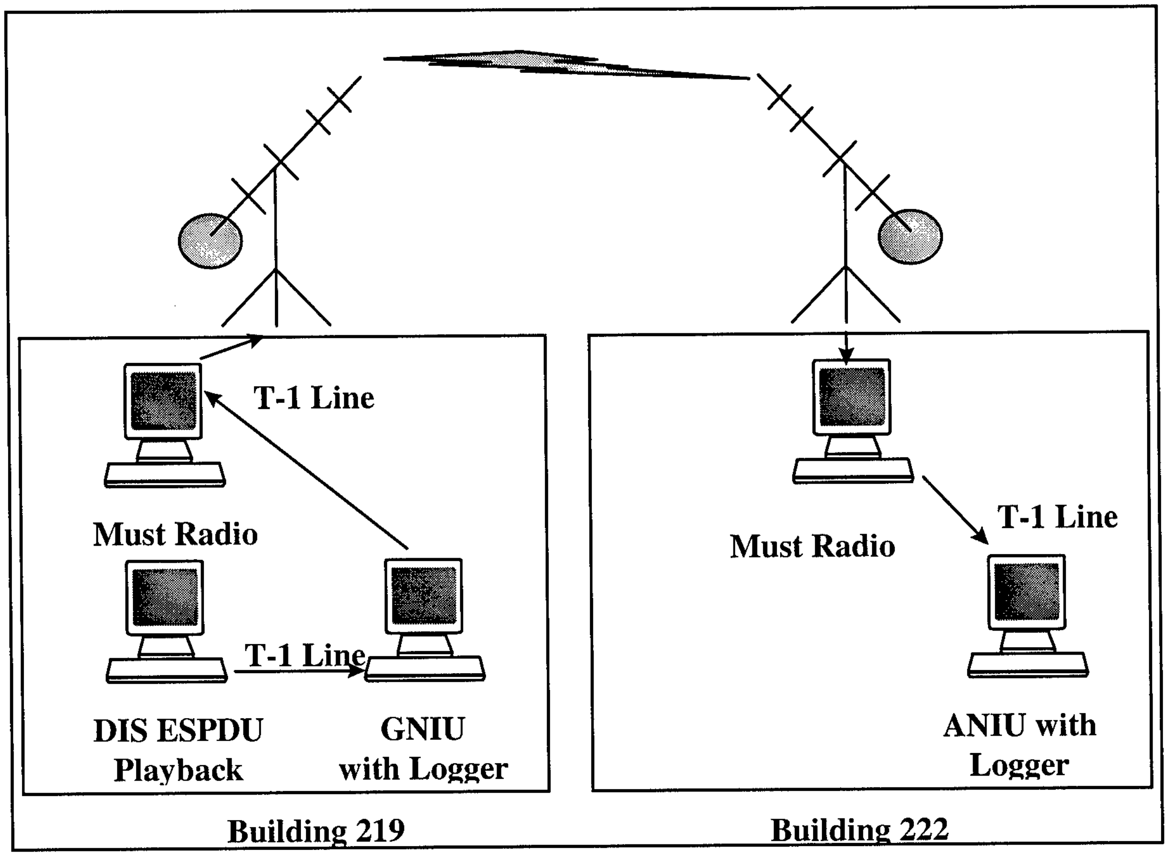


Figure 7. GNIU to ANIU Link Synthetic Environment

In this environment, ESPDUs from a Janus 6.88D scenario were sent to the GNIU, converted to VDPs and sent to a satellite transceiver (Must Radio) located in one of Northrop Grumman's laboratories. The VDPs were then transmitted to a communications satellite and retransmitted to another satellite transceiver (Must Radio) located in another Northrop Grumman laboratory. The output of the second satellite transceiver was recorded by a second Alpha workstation representing the ANIU. A review of the recorded satellite transceiver output showed an acceptable transmittal rate of 34 VDPs per second with buffering. At this rate, there were no dropouts and no corruption of the VDP packet.

Step 3: Laboratory Test of ANIU and RPSI Using Primary Mission Equipment

The software components of VSTARS that would be moved to the T3 E-8C were first moved to the radar components laboratory (RCL) and integrated into the primary mission equipment (PME). The RCL is used to test radar components and integrate software builds and is a duplicate of the equipment found on the aircraft. Once the software was installed and integrated, it was tested using the configuration shown in Figure 8.

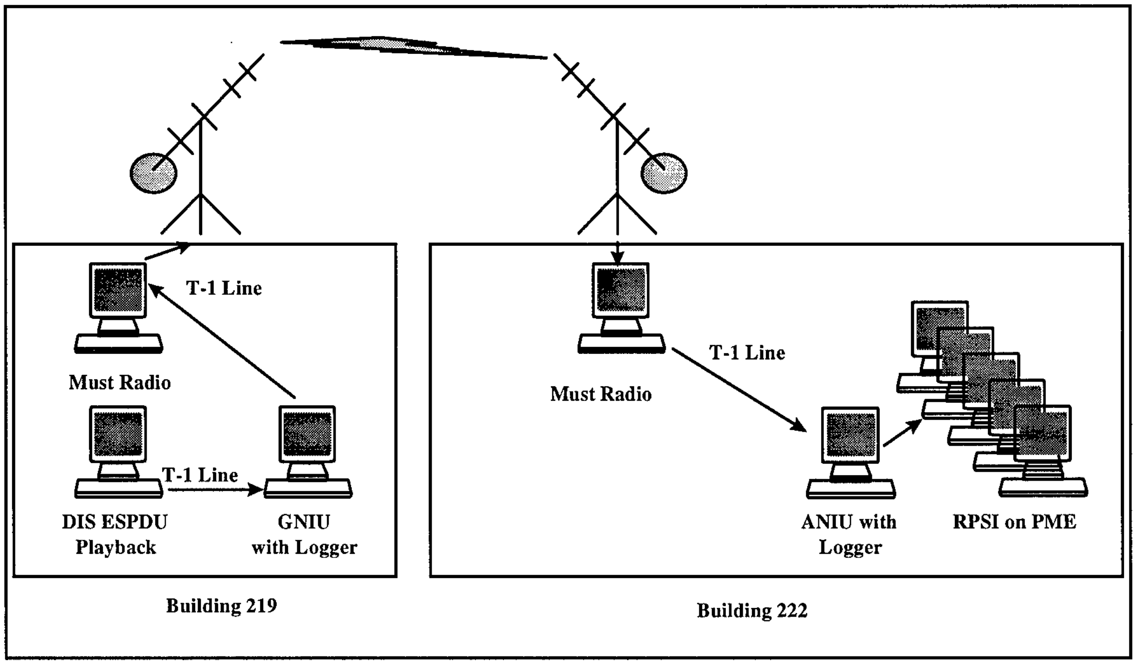


Figure 8. Laboratory PME Test of ANIU and RPSI

The integration of the ANIU and RPSI into the ETE Test ADS software build (JDS 07_006+) was tested by executing the Joint STARS JTF SITs and the Phase 3 V&V in the laboratory prior to moving the integrated build to the aircraft.

Step 4: Test of Build JDS 07_006+ Installed on the T3 E-8C

Following the successful testing of build JDS 07_006+ in the laboratory, it was replicated and installed on the PME onboard the T3 E-8C. The test environment consisted of ESPDUs from a Janus 6.88D scenario transmitted from a SGI JADS player or TRAC-WSMR to the ground NIU via a T-1 communications line. The ESPDUs were then converted to VDPs and transmitted to the air NIU on the E-8C via a SATCOM link. These data were then used by the RPSI to generate virtual radar reports, which were mixed with live radar reports from noise generated by a dummy load and sent out on the OWS local area network (LAN) to the workstations and via an actual SCDL to a ground station module sitting several hundred meters from the aircraft. Figure 9 depicts the configuration for this step.

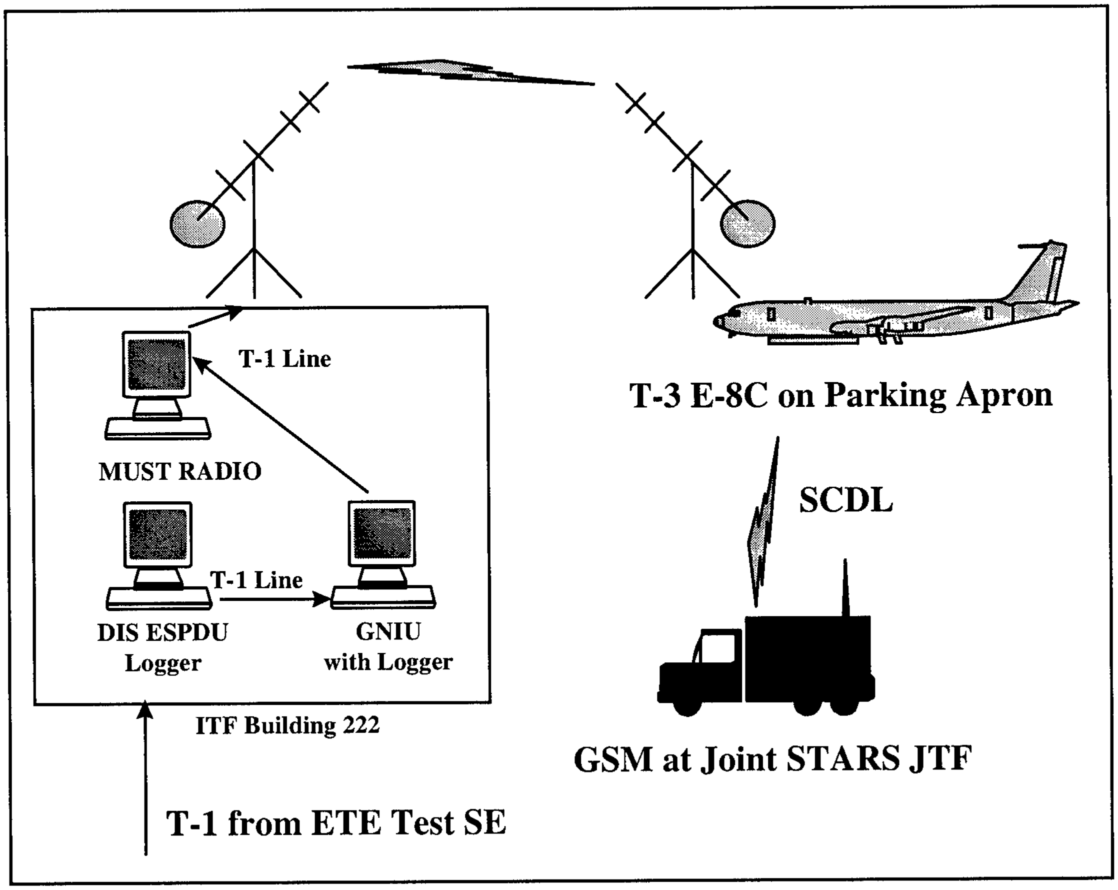


Figure 9. Synthetic Environment for Test of Build JDS 07_006+ Installed on the T3 E-8C

The SATCOM link between the GNIU and the ANIU was tested and characterized by Northrop Grumman and proper operation was verified.

Once it was ascertained that build JDS 07_006+ appeared to be functioning correctly, it was tested by the Joint STARS JTF executing the required SITs and Northrop Grumman personnel accomplishing the Phase 3 V&V.

System Integration Tests

The Joint STARS JTF required, prior to any test flight, that a series of SITs be conducted using the software build that would be flown during the flight. The SITs ensured the ability to use the subsystems onboard the aircraft (radar, advanced tactical workstations, communications, and SCDL) was not compromised in any way by the software changes and additions made to the radar build. The SITs were conducted using the T3 aircraft and an MGSM. V&V was conducted to ensure that the ADS-enhanced radar system met the requirements and acceptability criteria established by the ETE Test team.

The results from implementing the ETE Test Phase 3 V&V are detailed in the Phase 3 V&V reports and are summarized as follows. (ETE Test VV&A represented a tailoring and implementation of the nine-step process to a multiservice test of a major system, Joint STARS, augmented with ADS. The tailored ETE Test process model used is described in the V&V reports for the ETE Test. Available from JADS, 2050A 2nd Street SE, Kirtland Air Force Base, New Mexico, 87117-5522. After 1 March 2000 refer requests to HQ AFOTEC/HO, 8500 Gibson Blvd SE, Kirtland Air Force Base, New Mexico 87117-5558, or SAIC Technical Library, 2001 North Beauregard St. Suite 80, Alexandria, Virginia 22311.)

- Verification of the ADS-enhanced E-8C aircraft
  - The following were verified during the SITs
    - JDS 07_006+ permitted all of the aircraft subsystems to function normally
    - JDS 07_006+ processed parameter data in the same format as Joint STARS
    - JDS 07_006+ permitted all of the installed operator workstation software to function without abnormal fault messages occurring
    - JDS 07_006+ received and integrated virtual data from the ADS environment
    - JDS 07_006+ operated in three modes: live only, mixed live and virtual, and virtual only using the standard Joint STARS MTI message format
    - The radar timeline was not impacted by the MTI simulation
  - The requirement that JDS 07_006+ display live SARs in live areas of interest and virtual SARs in both virtual and mixed areas of interest using the standard Joint STARS SAR message format was not completely met. The software build contained an error, previously observed and corrected in VSTARS, that resulted in live SARs displayed in a mixed area of interest (in which only virtual SARs should have been displayed). Correction of this fault, though relatively easy, would have required a redo of both the SITs and that portion of the verification. Since the aircraft would not be available before the first flight, nor between the subsequent flights, for this additional testing, and the shortcoming would have no impact on the operational test, the decision was made to proceed with the test without this capability.
  - There was a problem with corruption of the data packets when sent via the satellite link. This problem manifested itself by identifying nonmoving targets as moving targets. One of the programmers had found it necessary to add thirty-two bits to the VSTARS data packet in order to separate the GNIU and the ANIU. The programmer working on the satellite link was not told this and continued to parse the data packets as 192-bit as opposed to 224-bit data packets. Once the error was found, it was corrected and that portion of the V&V was repeated prior to the Phase 4 flight tests.

- Verification of the SCDL
  - The SCDL was tested by the Joint STARS JTF during the conduct of the SITs onboard the aircraft.
  - The aircraft was linked to both the SCDL laboratory at Northrop Grumman and to a LGSM that belonged to the Joint STARS JTF. During this testing, it was verified that JDS 07_006+ could link to both the old SCDL format and the new SCDL format allowing its use with both GSMs and common ground stations (CGSs).

- Validation of JDS 07_006+. The validation of JDS 07_006+ was performed by the Joint STARS JTF operators who performed the SITs and included several of the operators who took part in the Phase 2 validation of VSTARS. It also included several operators who had not previously seen ADS-enhanced radar.
  - All of the operators were impressed with the performance of JDS 07_006+, and those that had previously tested VSTARS noticed no differences from the previously validated laboratory version. The operators that had not previously seen ADS-enhanced radar made the same comments as noted in the Phase 2 V&V report.

Conclusion for JADS Measure 1-1-0-1. The Phase 3 ADS configuration produced more valid data than the Phase 2 configuration. This was because of the increased use of actual processes and hardware. All simulation processes were functioning on actual SUT hardware using standard processes to include SCDL. The only simulations occurring were the simulations of the MTI, SAR and fixed target indicator (FTI) modes. These simulations ran parallel to the actual radar using its timelines and output standard radar reports. These reports were then mixed with the actual radar reports, as designated by the simulation manager, into live, virtual, and mixed radar reports. Events that degrade the quality of the data do occur, such as LAN collisions, but they occur equally to both real and simulated data.

Conclusion for JADS Measure 1-1-0-2. Under normal operations, all input data provided to the SUT (Joint STARS) by the ADS environment were valid. Network performance and reliability in delivering data to the SUT are analyzed under JADS Objective 2-1.

<u>Utility for OT&E</u>

The utility of this configuration for Joint STARS OT&E was evaluated by determining which measures from the Joint STARS Multiservice Operational Test and Evaluation (MOT&E) Plan[1] could be supported assuming the use of the E-8C aircraft on the tarmac, fully manned and linked to a fully manned LGSM. Appendix B (available under separate cover from JADS JTF) identifies which Joint STARS MOT&E measures could be evaluated using the Phase 3 ADS configuration.

Results in Appendix B are summarized as follows.

- The measures for critical operational issue (COI)-1 (Does Joint STARS perform its tactical battlefield surveillance mission?) involving the performance of the E-8 radar in its operational environment cannot be evaluated using the Phase 3 configuration. As a result, the Phase 3 configuration could be used to evaluate only 7 out of 18 measures of performance (MOPs) supporting COI-1. However, all three measures of effectiveness (MOEs) for COI-1 could at least be partially evaluated using the Phase 2 configuration.

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[1] *Joint Surveillance Target Attack Radar System (Joint STARS) Multiservice Operational Test and Evaluation (MOT&E) Plan*, Air Force Operational Test and Evaluation Center, Kirtland Air Force Base, New Mexico, 21 February 1995.

- As with COI-1, the measures for COI-2 (Does Joint STARS support the execution of attacks against detected targets?) involving the performance of the E-8 radar in its operational environment cannot be evaluated using the Phase 3 configuration. As a result, the Phase 3 configuration could be used to evaluate only 11 out of 24 MOPs, resulting in a very limited evaluation for 3 out of 3 MOEs supporting COI-2.

- The Phase 3 ADS configuration could be used to partially evaluate the single MOE supporting COI-3 (Does Joint STARS provide timely and accurate information to support battlefield management and target selection?).

- The Phase 3 ADS configuration could be used to evaluate 1 out of 2 MOPs for COI-4 (Can the Joint STARS system be sustained in an operational environment?).

- The Phase 3 ADS configuration could support the evaluation of 8 out of 17 of the additional effectiveness measures.

- The Phase 3 ADS configuration could support the evaluation of 13 out of 27 MOPs involving GSM or E-8C suitability.

- The Phase 3 configuration could allow for operational operators to be used which would allow for all 8 of the E-8C human factors measures to be addressed.

- The Phase 3 configuration could allow for evaluation of 6 out of 6 software system MOPs.

In summary, the Phase 3 ADS configuration could only allow an evaluation of 22 out of 45 effectiveness MOPs and a very limited evaluation for 7 of 8 effectiveness MOEs. Further, the Phase 3 ADS configuration could be used to evaluate the GSM measures (13 out of 27 suitability MOPs), all 8 of the E-8C human factors MOPs and all 6 software MOPs.

4.2 JADS Issue 2. What are the critical constraints, concerns, and methodologies when using ADS for T&E?

The evaluation of this issue was based on testing using the connectivity test configuration (T-1 lines only; no SATCOM link), rather than the Phase 3 ADS configuration (with SATCOM link).

4.2.1 JADS Objective 2-1. Assess the critical constraints and concerns in ADS performance for T&E.

4.2.1.1 JADS Subobjective 2-1-2. Assess network and communications performance constraints and concerns.

JADS Measure 2-1-2-2. Percentage of ADS trials canceled or otherwise not used due to network problems.

JADS Measure 2-1-3-3. Percentage of trials in which network connections were lost long enough to require trial cancellation.

For these measures, the network was defined as including all software and hardware used for connecting the distributed sites and all loggers and instrumentation used for recording network data. NIUs were considered part of the individual simulations and not part of the network.

For each trial, an execution log was maintained at each node. The data collectors annotated all problems encountered, including loss of connectivity in any link, as well as their causes. A test controller log also documented the overall status of the network and test trials. In addition, network monitoring tools were used to monitor the status of all network links between nodes. Any problems detected by the monitoring tools were documented via line printers in terms of a brief explanation of the problem, the time, and the link(s) involved.

There were no network problems which were serious enough to require delay or cancellation of any trials. Although there were some losses of connectivity (see Measure 2-1-3-6), these were of short duration and did not significantly impact the trials. During all previous ETE Test phases, significant network problems were experienced for at least a portion of the tests. The risk reduction efforts taken during these previous test phases helped to ensure the reliability of the network during the Phase 3 connectivity tests. Table 2 shows the dates of the trials and their test times. Note that there were some trial cancellations because of ADS system failures (see Measures 2-1-3-1 and 2-1-3-5) exclusive of network problems.

Table 2. ETE Test Phase 3 Connectivity Tests

Trial	Time Scheduled for Testing	Comments
25 February		Trial canceled because of VSTARS unavailability
26 February		Trial canceled because of VSTARS unavailability
10 March		Trial delayed and then canceled because of VSTARS unavailability
11 March	7 hrs, 37 mins	
12 March	6 hrs, 36 mins	

JADS Measure 2-1-2-3. Bandwidth utilized and packet rate by link.

This measure provided an indication of bandwidth use and packet rate during the Phase 3 connectivity tests. Although bandwidth utilization was not expected to exceed capacity, the utilization rate was documented to provide other ADS testers with an indication of the amount of needed bandwidth. The packet rate data are also included because of their potential value to other ADS testers.

Data were collected using the Spectrum™ network analysis tool. Spectrum™ provided the capability to study multiple aspects of network link performance including packet rate and percentage of bandwidth utilized. A polling rate of five seconds was used in the collection of these data.

Once all the data were gathered, the JADS analysts consolidated the data by network link. These data were then used to calculate daily packet rate and bandwidth values (maximum and average) for each link. The bandwidth values were provided by Spectrum™ as the percentage of bandwidth available on the T-1 line. A T-1 line has a normal bandwidth of 1.544 megabits per second (Mbps). For the ETE Test, some of the bandwidth of the T-1 line was reserved for voice traffic, leaving a maximum bandwidth available of 1.344 Mbps.

Table 3 shows average and maximum performance values for the classified network links monitored during the two days of active Phase 3 connectivity testing.

Table 3. Connectivity Tests Link Performance Characteristics*

Day	Node A	Node B	Load Average	Load Maximum	Packet Rate Average	Packet Rate Maximum
11 March	T	G	1.4%	73%	18.8/sec	331/sec
	G	H	0.1%	4%	6.2/sec	87/sec
	H	T	0.05%	3%	3.2/sec	14/sec
12 March	T	G	0.05%	1%	2.5/sec	19/sec
	G	H	1.0%	12%	24.3/sec	119/sec
	H	T	2.5%	19%	15.9/sec	54/sec

T = TCAC G = Northrop Grumman H = Fort Hood

* Table refers only to active test time during which PDU loggers were recording data.

Packet rate and bandwidth utilized differed greatly between the two days of testing because of a cryptographic equipment problem which impacted the TCAC-Grumman link prior to test start on 12 March. The link was not used to pass data traffic for about five out of the six hours of testing that day, during which time the data were automatically rerouted between the two sites using the alternate network path through Fort Hood until the problem was fixed. Although the flow of test data along this alternate path was transparent to the testers, analyzed packet rate and bandwidth data for the three network links were quite different between the two days. The packet rate experienced over the TCAC-Grumman link averaged approximately 19 packets per second on 11 March but only 2.5 on 12 March. The packet rate experienced over the Grumman-Fort Hood link jumped from an average of 6.2 packets per second on 11 March to 24.3 on 12 March, and the Fort Hood-TCAC traffic jumped from an average of 3.2 packets per second on 11 March to about 16 on 12 March. The latter two links took up the data traffic responsibility of the downed link, and testing continued without a hitch proving the utility of network link redundancy. The maximum packet rate for any network link during the two test days was 331 packets per second, experienced over the TCAC-Grumman link on 11 March, resulting in a peak load of 73 percent of bandwidth capacity. This high rate was of short duration (about 2 minutes) and appeared to be caused by file transfers during the trial rather than by normal PDU traffic. The greatest average load experienced across any of the three network links was 2.5 percent, showing the relatively small bandwidth utilization experienced during the Phase 3 connectivity test.

It is also noted that the average packet rates and bandwidth utilization rates measured on 11 March were consistent with values from the Phase 2 trials, showing the relative stability of the network.

JADS Measure 2-1-2-5. Percentage of time PDUs were received out of order by a network node.

JADS Measure 2-1-2-6. Percentage of total PDUs required at a node that were delivered to that node.

JADS Measure 2-1-2-7. Average and peak data latency between ADS nodes.

The flow of PDUs to and from each node was recorded using loggers installed as part of the network architecture. The loggers specifically recorded the time and order that the PDUs were transmitted and received at each node.

The raw logger data were transformed and reduced for analysis to determine out of order, duplicate or lost PDUs and PDU latency. These data were then used to calculate the percentage of out of order, duplicate, and lost PDUs at each node for each test day and for the connectivity test as a whole. The minimum, maximum, and mean latency of PDUs were also computed. JADS analysts accomplished these calculations using UNIX®-based software tools created by JADS programmers.

Table 4 shows the PDU data for each day by node; there were no duplicate or out of order PDUs. The PDU data in Table 4 show total PDU loss rates of 2.75, 0.48, and 1.71 percent for the WSMR-TCAC, TCAC-Northrop Grumman, and Fort Sill-WSMR links, respectively. Note that the total loss rate for ESPDUs generated by Janus being delivered from the WSMR node to the Northrop Grumman node (the node requiring them) was 3.22 percent (or 7,281 PDUs lost out of 226,440 PDUs sent).

The overall loss rate between WSMR and Northrop Grumman and between Fort Sill and WSMR was 3.18 percent. This PDU loss rate, while still well under the criterion of not using trial data with 5 percent or more lost PDUs, is considerably higher than the loss rate experienced during the Phase 2 test (0.075 percent). This resulted in large part from the PDU losses caused by the temporary outages of the WSMR-TCAC and Fort Sill-WSMR links on 12 March, as shown in Table 5. Table 5 gives the estimated PDU losses because of the loss of network link connectivity (estimated by correlating PDU time stamps with link outage times) and shows that 80 to 90 percent of the PDU losses were due to link connectivity losses. The overall loss rate because of causes other than link connectivity losses was about 0.7 percent which is much more consistent with the Phase 2 losses.

Table 4. Connectivity Tests PDU Data

Date	Node A	Node B	PDUs Sent	PDUs Received	PDUs Lost/ Percent Lost
11 March	W	T	93,896	93,872	24 0.03%
	T	G	93,872	92,837	1,035 1.10%
	S	W	2,618	2,617	1 0.04%
12 March	W	T	132,544	126,338	6,206 4.68%
	T	G	126,338	126,322	16 0.013%
	S	W	2,455	2,369	86 3.50%
Total	W	T	226,440	220,210	6,230 2.75%
	T	G	220,210	219,159	1,051 0.477%
	S	W	5,073	4,986	87 1.71%

W= WSMR T = TCAC G = Northrop Grumman S = Fort Sill

Table 6 shows the latencies measured during the Phase 3 connectivity tests. These data show that the average latency over the Fort Sill-WSMR link was very stable during the two days of testing and was within 10 percent of the Phase 2 value. The average latency over the WSMR-TCAC link was not nearly as stable. The WSMR-TCAC link average on 11 March was within about 5 percent of the Phase 2 value, but the average on 12 March was significantly higher. The latter value may be uncharacteristically high because of network problems with this link on that day.

As for the TCAC-Grumman link, no comparison could be made between the Phase 2 and Phase 3 latencies because of the Phase 3 connectivity tests' time synchronization problem which resulted in negative (i.e., invalid) latencies. This problem was resolved for the Phase 4 test.

Table 5. Connectivity Tests PDU Losses Due to Network Link Losses

Date	Node A	Node B	PDUs Sent PDUs Lost	PDUs Lost Due to Network Link Loss % of PDUs Sent / % of PDUs Lost
11 March	W	T	93,896 24	0 0% / 0%
	T	G	93,872 1,035	876 .93% / 84.64%
	S	W	2,618 1	0 0% / 0%
12 March	W	T	132,544 6,206	4,822 3.64% / 77.70%
	T	G	126,338 16	0 0% / 0%
	S	W	2,455 86	80 3.26% / 93.02%
Total	W	T	226,440 6,230	4,822 2.13% / 77.40%
	T	G	220,210 1,051	876 .40% / 83.35%
	S	W	5,073 87	80 1.58% / 91.95%

W= WSMR T = TCAC G = Northrop Grumman S = Fort Sill

Table 6. Connectivity Tests Latency Data

Date	Node A	Node B	Latency (seconds)		
			Minimum	Mean	Maximum
11 March	W	T	0.020	0.041	0.129
	T	G	----*	----*	----*
	S	W	0.037	0.038	0.375
12 March	W	T	0.020	0.053	0.172
	T	G	----*	----*	----*
	S	W	0.036	0.038	0.365
Total	W	T	0.020	0.047	0.172
	T	G	----*	----*	----*
	S	W	0.036	0.038	0.375

W= WSMR T = TCAC G = Northrop Grumman S = Fort Sill

* Logger clocks could not be synchronized at the Grumman node because of a problem with the time synchronization program. This problem resulted in negative latencies. However, the problem was resolved following testing on 12 March.

4.2.1.2 JADS Subobjective 2-1-3. Assess the impact of ADS reliability, availability and maintainability on T&E.

Intent. This subobjective examined the ability of the ADS systems (players and network) to be up and operating at scheduled test initialization and to remain up and operating throughout the duration of the test.

JADS Measure 2-1-3-1. Number of trials delayed, rescheduled, and/or reaccomplished because of failure of ADS systems, exclusive of network unavailability.

JADS Measure 2-1-3-5. Number of ADS system failures.

These measures determined the availability of ADS nodes including the NIUs and the impact of node failures on Phase 3 testing.

For each trial, an execution log was maintained at each node. The data collectors annotated all problems encountered with the ADS systems along with their causes. A test controller log was also maintained to document the overall status of the trials.

A total of seven ADS system failures occurred during the Phase 3 connectivity tests. Six of the seven failures involved VSTARS, with the other ADS system failure due to TAFSM. While the TAFSM failure resulted in only a 3-minute delay in running TAFSM and no impact on the overall trial, the VSTARS failures resulted in the cancellation of three test trials and the degradation of the SCDL during the remaining two trials.

The SCDL between the LGSM and VSTARS did not function properly during any of the Phase 3 connectivity tests. The LGSM at Fort Hood could send messages to VSTARS but received only garbled text messages and imagery. The SCDL failure was due to attempting to use the version of the RPSI developed for the aircraft on the laboratory Alpha workstations. This was attempted because the necessary offsets had been applied to this software, and it was desirable to verify that the offsets worked correctly with the Fort Hood GSM. Once it was determined that the JDS 07_006+ version of the RPSI would not work properly on an Alpha workstation, the original RPSI used in the Phase 2 test was resurrected and, after the proper offsets were applied, used for the Phase 4 testing.

Table 7 lists the reported ADS failures, along with the time needed to resolve these interruptions and their impact on testing.

Table 7. ADS System Failures

Day	Failure	Resolution	Duration	Test Time	Impact on Test
25 February	VSTARS not operational	Northrop Grumman unable to resolve for trial	N/A	N/A	Trial canceled
26 February	VSTARS not operational	Northrop Grumman unable to resolve for trial	N/A	N/A	Trial canceled
10 March	VSTARS not operational	Software adjustments for lab environment	N/A	N/A	Test startup delayed pending VSTARS fix
	SCDL not operational	Northrop Grumman unable to resolve for trial	N/A	N/A	Trial canceled
11 March	TAFSM crashed at Fort Sill	TAFSM rebooted	3 mins	7 hrs, 37 mins	No delay caused by TAFSM reboot
	SCDL not operational	LGSM rebooted; VSTARS SCDL checked; problem unresolved	6 hrs, 5 mins	7 hrs, 37 mins	Fort Hood received garbled imagery and messages via the SCDL for the entire trial
12 March	SCDL not operational	Northrop Grumman adjusted SCDL on VSTARS	6 hrs, 14 mins	6 hrs, 36 mins	Fort Hood received garbled imagery and messages via the SCDL for the entire trial

JADS Measure 2-1-3-6. Average down time due to ADS network failures.

This measure identified the impact of network failures on the Phase 3 test. During Phase 3, logs were kept to record all network problems, the start time and duration of the problems and problem resolution. In addition, network monitoring tools were used to monitor the status of all network links between the nodes. Any problem detected by the monitoring tools was documented via line printers in terms of a brief explanation of the problem, the time, and the link(s) involved.

Because of problems with VSTARS, not the network, the first two scheduled trials were not executed, and the third trial was not completed. For the two trials that were accomplished, only three network outages were experienced, resulting in a total of 11 minutes of network downtime during the Phase 3 connectivity tests. Table 8 displays the data on network downtime.

Table 8. Network Downtime

Date	Time Scheduled for Testing	Time Network Unavailable for Testing	Percentage of Time Network Unavailable	Reason Unavailable
11 March	7 hrs, 37 min	6 mins	1.31%	Router down at Northrop Grumman; unknown problem at Northrop Grumman
12 March	6 hrs, 36 mins	5 mins	1.26%	Unknown problem at WSMR
Total	**14 hrs, 13 mins**	**11 mins**	**1.29%**	

Table 8 shows that the network was reliable during the execution of the Phase 3 connectivity tests. During the two days of testing, the network was down for only 11 minutes or 1.29 percent of the test period resulting in few lost (2.5%) PDUs. The causes of two of the three documented network problems were unknown. There was a problem experienced at the Northrop Grumman node on 11 March that resolved itself before JADS N&E personnel could attempt to identify it. There was also an unidentified problem at WSMR on 12 March. This problem was examined by JADS N&E personnel but could not be readily identified. It is most likely that this problem was due to the severe weather experienced at WSMR which affected networks post wide. Again, this problem resolved itself and is not expected to be a factor during Phase 4 testing.

4.2.2 JADS Objective 2-2. Assess the critical constraints and concerns in ADS support systems for T&E.

4.2.2.1 JADS Subobjective 2-2-1. Assess the critical constraints and concerns regarding ADS data management and analysis systems.

JADS Measure 2-2-1-1. Degree to which ADS nodes provide for collection, data entry, and quality checking of pre- and post-trial briefing data.

Quick-look analysis of results was used to support the post-trial briefings. This analysis relied primarily on automated data collection at all ETE Test nodes. The data collection tools included the JADS logger which collected the PDU log files and a Spectrum™ logger to monitor network performance. Data collection tools were attached to the network at each node without any impact on network or node performance. At the end of each test day, the data were remotely retrieved by the TCAC and the file size checked. This procedure supported timely quick-look analysis and test feedback.

In addition to electronic data logs, manually written logs were kept at each test site and used to support post-trial briefings. In addition, a daily after-action teleconference call was added. This enabled the test controller to discuss and fully understand the problems of the day without having to review local log sheets.

JADS Measure 2-2-1-2. Adequacy of relevant test data storage at ADS nodes.

The ETE Test analysis requirements drove test data storage needs. The focus of data analysis at each site was on network latency, as well as the actual PDU input or data output at each site. The need to record PDU traffic at each node required a determination of the data output and reception rates at all sites. The largest contributor to ESPDU traffic was the output of the Janus simulation. ESPDUs from Janus are a function of the Janus heartbeat and the vignette design. During the Phase 3 testing, the Janus heartbeat was set to update all entities every eleven minutes during the first hour. In addition, Janus had to output an ESPDU when an entity changed state, i.e., start, stop, turn, etc. As a result, the ESPDU output grew as the number of movers increased. The ETE Test used five different vignettes, ranging from prehostility with low numbers of movers to an active battle vignette with more than 3,000 entities moving at one time. Prior to Phase 2 testing, the five vignettes were played and the ESPDU output recorded. The maximum file size during this testing was about fifteen megabytes. To support the data recording as well as file storage and local software requirements, the JADS N&E team installed 4-gigabyte hard drives on the SGI Indy at each node.

During preparations for the Phase 3 test, the Northrop Grumman node required the largest data capacity in order to support VSTARS software testing in a stand-alone mode. This testing required the playback of PDU files recorded from TRAC-WSMR to VSTARS. All five vignettes were played back at various times, and at least five vignette PDU files were stored on the SGI Indy at all times. During actual Phase 3 testing, the ETE Test team found hard drive data storage capacity to be more than adequate.

The development of data storage needs required a full understanding of each node's requirements. Since the cost of hard drive storage has decreased dramatically over the past few years, it was cost effective to allow for unexpected growth by significantly exceeding the expected storage requirements.

5.0 Lessons Learned

5.1 Technical Lessons Learned

5.1.1 Interfaces

Distributed testing often requires linkage among dissimilar facilities, network equipment, and simulations. However, careful planning can significantly reduce the potential for difficulties arising from network interface problems. As part of their planning, the ETE Test team bought standard network equipment for all of the sites. Thus, the configuration of the ETE Test environment did not pose any problems during the Phase 3 test.

5.1.2 Instrumentation

Special equipment was necessary for ADS network check-out and verification. Special test equipment and networking tools will rapidly isolate the specific cause of network and ADS/DIS problems. Without the special equipment, troubleshooting would have been accomplished by trial and error increasing time, cost, and personnel. In addition, the key N&E personnel should be trained in the use of the special test equipment and networking tools.

5.2 Infrastructure and Process Lessons Learned

5.2.1 Procedures

5.2.1.1 Planning

The requirements for an ADS test must be clearly defined early in the test planning phase. Detailed planning and coordination are required to ensure a common understanding of all requirements, procedures, and test objectives since individual facilities are generally unfamiliar with conducting coordinated, distributed T&E tests. Phase 3 testing succeeded because of close planning and coordination among the ETE Test team and the supporting facilities at the various nodes.

5.2.1.2 Development

Risk reduction testing prior to actual test execution will help test team personnel identify and resolve potential ADS system problems. At the Northrop Grumman node, extensive laboratory testing paved the way for the successful Phase 3 tests.

5.2.1.3 Execution

Briefings are needed before and after each ADS test. These briefings should include such information as the test objectives, telephone numbers to use for test control, the test configuration of each facility, instrumentation and data collection requirements, go/no go criteria, contingency and backup plans, and test conduct. A briefing checklist should be developed and used.

5.2.1.4 Evaluation

Effective data management is needed. Linked facilities can generate a large volume of data at distributed locations. Without careful planning, key data may not be collected and/or transmitted to the analysis center, and data collected at the network nodes may not be in a useful form for centralized analysis. Before ADS testing, a comprehensive data management plan must clearly identify the data to be collected at each network node, onsite processing of the data, and the data to be transmitted to the analysis center.

5.2.1.5 Command and Control

Have test controllers who are extremely familiar with the test and network configuration. The test controller for Phase 3 had acted as test controller during the Phase 2 testing.

Have a centralized test control center. The JADS TCAC is configured to allow for convenient, instant communications with all the nodes. It acted as the central point of contact between the nodes and for all problems. The test controller kept track of test progress and documented any problems that occurred.

5.2.2 Policy

Network management and troubleshooting must be disciplined and organized with a thorough understanding and strong configuration control of the ADS network.

5.2.3 Personnel

Personnel involved in a distributed test should understand the "big picture." When problems arise, personnel who understand the entire test and the overall network will find solutions much faster. During Phase 3, the ETE Test team personnel were stationed at the same locations as they were during Phase 2 to take advantage of the experience gained during Phase 2.

6.0 Conclusions/Recommendations

The Phase 3 architecture was essentially a transition between the Phase 2 and Phase 4 architectures and did not involve any C4ISR DT&E or OT&E. Thus the following conclusions and recommendations are based on cumulative ETE test experience.

6.1 Utility

6.1.1 Utility Conclusions

6.1.1.1 Enhanced Testing. An ADS environment can enhance the testing of C4ISR systems.

Compared to conventional methods, an ADS environment can realistically test C4ISR systems

- with larger numbers of ground-based entities at a much lower cost.
- for longer periods of time, enabling increased data collection and the ability to analyze and improve the data gathering process.

By allowing the simulation of large battlespaces with large numbers of entities, ADS technology provides testers with greatly expanded capabilities for test concept and design.

Testers can use ADS to save time, resources, and test personnel man-hours by linking several pieces of equipment and/or facilities together for simultaneous testing instead of conducting individual tests at different locations.

6.1.2 Utility Recommendations

Large exercises could use the ETE Test environment to virtually augment the battlefield with simulated targets. During Phase 4, this capability will be demonstrated with the integration of a live E-8C Joint STARS aircraft into the ETE Test ADS environment.

An ADS environment, like the ETE Test environment, is flexible enough to allow for further expansion and increased opportunities for testing C4ISR systems. The Janus battlespace can be expanded as required. Increasing the number of LGSMs or CGSs would create more realistic targeting capabilities. By adding other assets to the environment, such as an unmanned aerial vehicle (UAV) or a tactical aircraft simulator, the robustness of the environment could be significantly enhanced.

6.2 Technical

6.2.1 Technical Conclusions

The ETE Test network was highly reliable during Phase 3 testing.

As expected, the Phase 3 testing at the Northrop Grumman node showed that all of the available satellite link bandwidth was required for data transmission, and that buffering was needed at times to handle periods of heavy scenario activity. Without buffering, the satellite link exhibited a normal latency of around two seconds. With buffering, the latency approached six seconds. Neither of these latencies was observable in the radar reports, indicating that the ETE Test synthetic environment is very tolerant of latencies in this range. However, ADS test planners need to consider these factors when testing other C4ISR systems involving satellite links.

6.2.2 Technical Recommendations

With careful planning and resource management, testers can address the issues associated with integrating simulations into an ADS test environment.

- Identify the assumptions and limitations associated with those simulations.
- Budget, schedule, and provide the manpower necessary to develop the simulations. Simulation development is typically labor intensive and thus costly.
- Determine the level of simulation detail needed for the ADS test. Development costs are directly related to the level of simulation detail.
- Identify and provide training for the users of the simulations.

6.3 Infrastructure

6.3.1 Infrastructure Conclusions

ADS can reduce the number of troops and associated equipment involved in tests because of its simulation of fielded forces. However, the ADS infrastructure requires technical personnel to set up and execute the tests and to analyze the test results.

Highly structured test control is a key ingredient for ADS test success. This test control should include formalized procedures with an emphasis on checklists.

An ADS test can't always count on having the personnel requirements for a distant node supplied by an organization local to the node. Even if an ADS test is able to employ these people, it may then lose them to other activities deemed more important by the local organization. During Phase 3, the ETE Test team deployed two of its most experienced members to the Northrop Grumman node to ensure effective communication and coordination with the activities occurring at this node.

An ADS environment necessitates sophisticated instrumentation with rigorous processing speed, data storage, and data integration capabilities. This instrumentation can be costly and can require trained personnel for its successful operation.

ADS analysts must have a well-planned and organized approach to managing the large amounts of data produced from ADS testing.

6.3.2 Infrastructure Recommendations

Make every effort to simplify the infrastructure. Time spent in the planning stages of an ADS test, with an emphasis on reducing the complexity of the test network, is time well spent. Use proven hardware and keep it the same wherever possible.

APPENDIX A – JADS Test Procedures

A1.0 Test Procedures

Various types of checklists were used during the execution of the Phase 3 test. The Test Control and Analysis Center (TCAC) test controller checklist can be found in Section A1.1, *TCAC Test Procedures*. This checklist was used to ensure network and logger functionality and to provide overall test control procedures. Each node (White Sands Missile Range [WSMR], Northrop Grumman, and Fort Sill) incorporated the logger functions from the TCAC checklist into their own checklist.

Other checklists were used to direct the operation of various pieces of test equipment. An example is included in Section A1.2, *TCAC Plan View Display (PVD) Procedures.*

Section A1.3, *WSMR Procedures,* is representative of the site-specific checklists. WSMR, Northrop Grumman and Fort Sill all developed procedures for operation of the End-to-End (ETE) Test environment equipment. Only Fort Hood, the only site without a logger, failed to develop written procedures. Their procedures were primarily accomplished by resident specialists having their own procedures.

A1.1 TCAC Test Procedures

The following are the written test procedures used in the TCAC during Phase 3 testing.

72 HOURS PRIOR TO TEST

Network Coordinator: ______________________

Date: ___________ Test Time: ___________ to ___________

1. _________ Check supplies.

2. Turn on equipment.

_________ a. Turn on 3 Barcos (Spectrum [Sun5] on 1, Janus [hp735] on 2, and NetVis [indigo2] on 3).

b. Log in as "root" to **indigo2** in the TCAC, and **indy4** in communications room 1.

_________ 1) From the toolchest, select Toolbox, JADS Toolbox, Monitor, PDU Monitor, PDU Statistics, Show Stats to display protocol data units (PDUs).

_________ 2) From the toolchest, select NetVis, NetGraph-ETE to display network traffic.

_________ 3) From the toolchest, select NetTests, Status check ETE to start and display network connectivity tests. (**uts** in comm rm 1 pings **wsmr, ftsill**, and **fthoodafatads**. **indigo2**, pings, **grumman**, **indy3**, and **sparc5** at Ft Hood).

_________ c. In the TCAC, run Spectrum on the **Sun20** (server) and **Sun5** (graph) to display Zulu time and router status.

_________ d. Create an empty file "`touch /scripts/.go`" in grumman, indigo2, and indy4.

3. _________ <u>Clear router interfaces</u>. To clear the **grumman_router**, **jads_router**, and **fthood_router** from **indigo2**; and **fthood_router**, **ftsill_router**, and **wsmr_router** from indy4, run: "**`/scripts/clear_router ete.`**"

4. _________ <u>Not used</u>.

5. <u>Time accuracy</u>. Verify that each site has network time protocol (**NTP**) running.
   - _________ a. From **uts**, run "**`/scripts/check_time`**" and verify that the offsets for **ftsill** and **wsmr** are less than 1 millisecond (ms).
   - _________ b. From **indigo2**, rlogin to **indy1**, run "**`/scripts/check_time.`**" Verify offsets for **grumman**, **indy3**, and **sparc5** are less than 1 ms.

6. <u>Available disk space</u>. Verify that each logger has at least **600 megabytes (MB)** of unused disk space available on the **/disk2** partition.
   - _________ a. From **uts**, rlogin to **ftsill** and **wsmr,** in turn, and from **indigo2**, rlogin to **grumman**, and **indy3**, in turn.
   - _________ b. Run "**`df -k`**" on each machine (including **uts**) to display the available disk space. Verify that each has at least **600 MB** available.

7. <u>Port settings</u>. Verify that each logger is set to port **3000** and the exercise identification (ID) is **0**.
   - _________ a. From **uts**, rlogin to **ftsill** and **wsmr,** in turn, and from **indigo2**, rlogin to **grumman**, and **indy3**, in turn.
   - _________ b. Run "**`more /scripts/dt_logger`**" to view the file. Look for the entry: "**`/usr/local/bin/jads_logger 3000 0 /disk2/logfiles /$testdate"_test"$testnum"_"$runnum"_"$site".log"`**" entry in two places.

8. _________ <u>Voice conference net</u>. Verify the net is functional by dialing in from two different phones in the TCAC at the same time to establish the net.

9. _________ <u>Not used</u>.

10. <u>Data collection test a</u>:
    - _________ a. From **uts**, rlogin to **ftsill** and **wsmr,** simultaneously, and from **indigo2**, rlogin to **grumman**, and **indy3**, simultaneously.
    - _________ b. Start the **ftsill**, **grumman**, **indy3**,and **uts** loggers using test number "**`000`**" and run number "**a**" (i.e. - "**`/scripts/dt_logger 000 a`**").
    - _________ c. Run the "**`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`**" file on the **wsmr** machine.
    - _________ d. Determine when run is complete. Stop all loggers ("**`Ctrl-C`**").
    - _________ e. Check digital communications terminal (DCT) results. Verify reception of **2281** PDUs on **grumman**, **indy3**, and **uts** (or **indy4**) loggers. (No PDUs at **ftsill**).

11. <u>Data collection test b</u>:
    - _________ a. From **uts**, rlogin to **ftsill** and **wsmr,** simultaneously, and from **indigo2**, rlogin to **grumman**, and **indy3**, simultaneously.
    - _________ b. Start the **grumman**, **indy3**, **uts** and **wsmr** loggers using test number "**`000`**" and run number "**a**" (i.e. - "**`/scripts/dt_logger 000 a`**").

_________ c. Run the "**`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`**" file on the **ftsill** machine.

_________ d. Determine when run is complete. Stop all loggers ("**`Ctrl-C`**").

_________ e. Check DCT results. Verify reception of **2281** PDUs on **grumman**, **indy3**, and **uts** loggers.

12. _________ Report the results of the network checks to the test controller. Supervise repairs as necessary to prepare equipment for the test sequence.

PRETEST (DAY OF TEST)

Network Coordinator: ________________________

Date: ____________ Test Time: ____________ to ____________

1. _________ Check supplies. Provide checklists, blank log sheets, file name lists, pens, pencils, scratch paper, and 4 millimeter (mm) tape cartridges for the test.

2. Turn on equipment.

_________ a. Turn on 3 Barcos (Spectrum [Sun5] on 1, Janus [hp735] on 2, and NetVis [indigo2] on 3).

b. Log in as "root" to **indigo2** in the TCAC, and **indy4** in communications room 1.

_________ 1) From the toolchest, select Toolbox, JADS Toolbox, Monitor, PDU Monitor, PDU Statistics, Show Stats to display PDUs.

_________ 2) From the toolchest, select NetVis, NetGraph-ETE to display network traffic.

_________ 3) From the toolchest, select NetTests, Status Check ETE to start and display network connectivity tests. (**uts** in Comm Rm 1 pings **wsmr, ftsill**, and **fthoodafatads. indigo2**, pings, **grumman**, **indy3**, and **sparc5** at Ft Hood).

_________ c. In the TCAC, run Spectrum on the **Sun20** (server) and **Sun5** (graph) to display Zulu time and router status.

3. Clear router interfaces. To clear the **grumman_router**, **jads_router**, and **fthood_router** from **indigo2**; and **fthood_router**, **ftsill_router**, and **wsmr_router** from indy4, run:

_________ "**`/scripts/clear_router ete.`**"

4. _________ Not used.

5. Time accuracy. Verify that each site has **NTP** running.

_________ a. From **uts**, run "**`/scripts/check_time`**" and verify that the offsets for **ftsill** and **wsmr** are less than 1 ms.

_________ b. From **indigo2**, rlogin to **indy1**, run "**`/scripts/check_time.`**" Verify offsets for **grumman**, **indy3**, and **sparc5** are less than 1 ms.

6. _________ Available disk space. Performed at each logger by the logger operator.

7. _________ Port settings. Performed at each logger by the logger operator.

8. _________ Join the voice conference net. Both the test controller and the network coordinator (NC) dial **61143** in the TCAC to establish the conference net.

9. _________ Time synchronization. **ftsill**, **grumman**, **indy3**, and **wsmr** operators check global positioning system (GPS) time reception by typing "**`date`**" and press **Enter** on the NC's mark. Report time to NC.
(NOTE: **indy1** is time server for classified, **uts** is time server for unclassified.)

10. Data collection test a:
_________ a. Cue **ftsill**, **grumman**, **indy3**,and **uts** operators to start loggers using test number "**`000`**" and run number "**`a`**" (i.e. - "**`/scripts/dt_logger 000 a`**").
_________ b. Cue **wsmr** operator to run "**`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`**" file.
_________ c. Determine when run is complete. Cue all operators to stop loggers ("**`Ctrl-C`**").
_________ d. Check DCT results - Have **grumman**, **indy3**, and **uts** operators verify reception of **2281** PDUs. (No PDUs at **ftsill**).

11. Data collection test b:
_________ a. Cue **grumman**, **indy3**, **uts**, and **wsmr** operators to start loggers using test number "**`000`**" and run number "**`b`**" (i.e. - "**`/scripts/dt_logger 000 b`**").
_________ b. Cue **ftsill** operator to run "**`/scripts/run_player 3000 /disk2/logfiles/ne_test.log`**" file.
_________ c. Determine when run is complete. Cue all operators to stop loggers ("**`Ctrl-C`**").
_________ d. Check DCT results - Have **grumman**, **indy3**, **uts**, and **wsmr** operators verify reception of **2281** PDUs. (No PDUs at **ftsill**).

12. _________ Report the results of the network checks (items 9-11) to the test controller.

The pretest phase is now complete. Proceed to the test run phase.

NOTE: Sometimes the logger process does not terminate on the **grumman** logger. In that case, run **`/scripts/find_logger`** on the **grumman** logger to kill the process and delete the old logfile before restarting the logger with the same filename.

TEST RUN

Network Coordinator: ____________________

Date: __________ Lab Time: __________ to __________

1. _________ Start loggers. Obtain the test and run numbers from the test controller and record on the log sheet. Operators are cued by the test controller when to start loggers. Record start time on the log sheet.
_________ a. Early in the test run, verify with operators that all loggers are receiving PDUs (number is increasing.
_________ b. Periodically check with operators that all loggers continue to receive PDUs (number is increasing).

_________ c. Periodically check "bat" phone operation if not used regularly.

_________ d. Every ½ hour, run a time accuracy check. From **uts**, run "**`/scripts/check_time`**" to check **ftsill** and **wsmr**. From **indigo2**, rlogin to **indy1** and run "**/scripts/check_time**" to check **`indy1`**, **grumman**, and **tcacindy**. Time offsets should be **<1** ms.

_________ e. Keep written event log.

2. <u>Stop loggers</u>. Loggers stop recording data when directed by the test controller ("**Ctrl-C**").

_________ a. Record the stop time and the total number of PDUs from each logger on log sheet.

_________ b. Confirm that the required data have been logged. From **uts**, rlogin to **ftsill** and **wsmr** and run "**`ls -l /disk2/logfiles.`**" From **indigo2**, rlogin to **indy3**, and **grumman** and run "**`ls -l /disk2/logfiles`**." Check the file sizes; the filename is "***mmddyy_test#-run#_loggername*.log.**"

3. _________ <u>Subsequent runs</u>. When additional runs are required, repeat steps 1 and 2 for each run.

The test run phase is now complete. Proceed to the post-test phase.

POST TEST (DAY OF TEST).

Network Coordinator: ______________________

Date: ___________ Test Time: ___________ to ___________

1. <u>Remote file capture</u>. Consolidate, compress, and copy the test run logger files from each remote site.

_________ a. For classified data, rlogin to each logger (**grumman** and **indy3**), in turn, from **tcacindy** in the TCAC, or
For unclassified data, rlogin to each logger (**ftsill**, **wsmr**, and **uts**), in turn, from **uts**.

_________ b. If only 1 file for the day exists in the logger at a site, skip to step c. If more than 1 log file for the day exists at a site, consolidate them by using the command
"**`tar cvf`** ***`mmddyy_sitename`*** **`.log.tar`** ***`mmddyy`*** **`*.log`** "
where * is the wildcard character that includes all the files for that day for that site name.
(e.g., - "**`tar cvf 040798_wsmr.log.tar 040798*.log`**").

_________ c. Compress the single log file (e.g., - "**`compress 040798_wsmr.log`**") or the tar file from step b ("**`compress 040798_wsmr.tar`**").

_________ d. On **tcacindy**, run "**`/scripts/rcp_etefile`**" to copy the tar'd and compressed classified files ("***mmddyy_sitename*.log.Z**") from both **grumman** and **indy3** loggers to **tcacindy:/disk2/ete/*mmddyy*/.**

_________ e. On **uts**, run "**`/scripts/rcp_etefile`**" to copy the tar'd and compressed unclassified files ("***mmddyy_sitename*.log.z**") from **ftsill**, **uts**, and **wsmr** loggers to
_________ **uts:/disk2/ete/*mmddyy*/.**

_________ f. Copy the unclassified files from step e to 4mm tape and activate the write protect feature.

g. Move the tape to **tcacindy** and copy the unclassified files from the tape to **/disk2/ete/*mmddyy*/** (i.e., from the **ete** directory, run **`tar xv`** to extract the files from the tape to the hard drive). **Make sure the write protect feature is ON.**

2. <u>Backup tapes</u>.

_________ a. Create a backup tape of the files in **tcacindy:/disk2/ete/*mmddyy*/** using either the "`tar cv mmddyy`" command while in the **ete** directory (or the tape tool on the **tcacindy** desktop).
b. Verify the backup using either the "`tar tv`" command or the tape tool.
_________ c. Remove the tape from the drive and label it.
_________ d. Repeat a, b, and c to create a duplicate tape.
_________ e. Deliver both tapes to the ETE Test team representative.

3. _________ Delete the data collection test and the backed-up log files from **/disk2/logfiles/** on all loggers.

4. _________ On the last day of testing, delete the file "`/scripts/.go`" in grumman, indigo2, and indy4.

5. _________ Logoff from logger. Turn **Off** the monitor, but leave the central processing unit (CPU) **On**!!!

6. _________ Participate in mission debrief, if applicable.

A1.2 TCAC Plan View Display (PVD) Procedures

The following procedures were used to initiate test monitoring with the Janus plan view display program. This is representative of the specific checklists developed to aid in the operation of test equipment.

Functionality/Integration Test Checklist (TCAC-PVD)

Date: ____________________
Scenario: ____________________

Test Start Time (z): ____________ Test Stop Time (z): ____________
Scenario Start Time: ____________ Scenario Stop Time: ____________

Step #	POC	Action	Event	Go/No Go
Run PVD				
1	ETE	Power on the hp735 monitor. Log on to the hp735 as **hovey**.		
2	ETE	From the xterm window that appears, type *pvd*, and hit ***enter***.	Use this alias to start Janus plan view display.	
3	ETE	From the Janus plan view display menu, verify the parameters for the run:		

		Workstation *1* Terrain File _____ Screen File _____ Symbol File *3* Symbol Size *10* Terrain File Meridian *45* Exercise ID ***BLANK*** Map Spheroid *1* Mode ***BLANK*** Terminate this Run *N* and hit ***keypad enter***.	Use the correct terrain file and screen file for the vignette.	
4	ETE	Wait until the PVD terrain and combat systems databases are loaded.	Last message: Opening file *../jads_ete/trn/TSCRN__. DAT*	
5	ETE	Double click the *Analyst_Workstation_WS1* icon to bring up the scenario window.		
6	ETE	From the *Analyst_Workstation_WS1* scenario window, functions menu, left click **Draw CAC**.		
7	ETE	From the *Analyst_Workstation_WS1* scenario window, CAC File menu, select the CAC file number to display. Left click increases number, and right click decreases number. Left click **Add** to display the CAC.	Places command and control overlays on the scenario box.	
8	ETE	From the *Analyst_Workstation_WS1* scenario window, function menu, left click **Display**.	Ready to receive and display DIS PDUs.	
9	ETE	From the *Analyst_Workstation_WS1* scenario window menu: Left click any **tick** on the zoom in/out menu, then select the	Used as necessary to zoom in/out of the scenario box.	

		desired zoom point on the scenario box. Left click **CAC**. Left click **Display**. Left click **Clear**.	Used as necessary to add or remove the command and control overlays which have been added in step 7. Used as necessary to start or stop Janus plan view display from receiving PDUs. Used as necessary to clear any text or information displayed on the scenario box. NOTE: A particular function is active when highlighted.	

Step #	POC	Action	Event	Go/No Go
Stop PVD				
1	ETE	From the *Analyst_Workstation_WS1* scenario window, right click **End**.	Shuts down PVD.	
2	ETE	Minimize the *Analyst_Workstation_WS1* scenario window.	In the xterm that remains, verify this message: STOP -----JANPVD Program Terminated-----	
3	ETE	From the *Analyst_Workstation_WS1* icon, right click and choose close.	Closes the scenario window.	

Step #	POC	Action	Event	Go/No Go
Shut Down Test				
1	ETE	Left click **EXIT** from the HP VUE front panel.	Signs off the hp735.	

2	ETE	Left click *Continue logout* from the dialog box.	Confirms desire to log out.	
3	ETE	Power off the hp735 monitor.		

A1.3 WSMR Procedures

This checklist is representative of the individual site checklists. It incorporates the logger functionality and the site specific actions required by the operator(s). These are maintained by the site specialists and updated as changes are required.

Functionality/Integration Test Checklist (WSMR)

Date: ____________________
Scenario: ____________________
Janus File: ____________________
Indy File: ____________________

Test Start Time (z): ____________ Test Stop Time (z): ____________
Scenario Start Time: ____________ Scenario Stop Time: ____________

Step #	POC	Action	Event	Go/No Go
Network Activation				
1	ETE and N&E	Verify operation of hotlink phone. If no go, contact N&E to fix the network.	Enables secure and unclassified voice communications.	
2	ETE and WSMR	Verify that WSMR indy and the WSMR hp715 are on the JADS ETE network.	Initial step in ensuring network is operational.	
3	N&E	Verity N&E has cleared and reset routers.	Clears router interface cards.	
4	ETE	Power on the WSMR monitor. Log on to WSMR as **dislog**. From a Unix shell window as **su**, run */scripts/restart*.	Restarts the indy.	
5	ETE	After a successful restart, log on to wsmr as **dislog**.	Signon is used for checking network communications and logging PDU data.	

6	ETE	From a Unix shell window as **su**, run */scripts/ping_test* to get ping statistics for each remote site.	Verifies that each network link is operational. 3% loss at Fort Sill and uts is normal.	

7	ETE	From a Unix shell window as **su**, run */scripts/check_time.*	Displays the offset from uts. Should be less than 1 ms.	
8	ETE	From a Unix shell window as **su** and at the test controller's direction, run */scripts/run_player 3000 /disk2/logfiles/ne_test.log* to check ability to send PDUs to each remote site.	Verifies sending 2281 PDUs and receiving the same number of PDUs at each remote site.	
9	ETE	From a Unix shell window as **su** and at the test controller's direction, run */scripts/dt_logger* _____ _____ to check ability to receive PDUs from a remote site. At the test controller's direction, hit **Ctrl-C** to end the logfile.	Verifies receiving 2281 PDUs from a remote site.	
10	ETE	From a Unix shell window, *cd /usr/local/bin* and run *./display_pdu_rate.* Select port ***3000 0.*** Left click ***start***.	Verifies that PDU_rate = 0. Ensures that there aren't any DIS communications before the start of testing.	

Step #	POC	Action	Event	Go/No Go
Start WSMR Logger				
1	ETE	From a Unix shell window as **su** on WSMR, run */scripts/dt_logger* ___________	Script that runs the JADS logger.	
2	ETE	Verify the logfile name as */disk2/logfiles/___________wsmr.log* and port 3000.	Opens port 3000 to listen and log all DIS communications. Writes to the listed logfile.	

Step #	POC	Action	Event	Go/No Go
Start Janus				
1	ETE	Power on the c180 monitor. Log on to the c180 as **JADS.**		
2	ETE	From an hpterm window, type ***janus.exe***, and hit ***enter***.	Use this executable to start Janus.	
3	ETE	Left click ***PE*** (Program Execution) from the Janus User Options menu.	Brings up the Program Execution menu.	
4	ETE	Left click ***JE*** (Janus Execution) from the Program Execution menu.	First step in defining the scenario.	
5	ETE	Type desired scenario number _____ for the run, and hit ***enter***. Type run number *1*, and hit ***enter***.	Tells Janus which scenario to run.	
6	ETE	Hit ***enter*** again to continue.	Ready to continue.	
7	ETE	Verify that ***1*** is entered. Hit ***enter*** one more time.	Use a normal run.	
8	ETE	From the Janus Runtime Screens menu, left click ***11***. Verify time of day is correct for the vignette, and hit ***keypad enter***.	Verifies time of day.	

9	ETE	From the Janus Runtime Screens menu, left click ***22***. Verify that there is a setup for: *WS Number 1*,and *Side 1*, and hit ***keypad enter***.	Verifies that a controller workstation has been configured.	
10	ETE	From the Janus Runtime Screens menu, left click ***66***. Verify the DIS operational parameters for the run: Janus side ***1*** DIS side ***2*** DIS COMM calls/sec ______ Units processed/COMM call ______ Terrain File Meridian (+E) ***45*** Heartbeat(s) ______ Dead Reckoning Threshold ***999*** Site ***TRAC-WSMR 23*** Host CPU ***HP 4*** Exercise ***JADS-ETE 4*** DIS version transmit ***4*** DIS version receive ***4*** and hit ***keypad enter***.	Verifies DIS parameters. Calculate the new heartbeat as follows: $C \times R \times H \leq T$ where C = calls/sec, R = units/call, H = heartbeat, and T = total number of units in scenario	
11	ETE	Left click ***JJ*** (Begin Janus) from the Janus Runtime Screens menu.	Loads the Janus scenario.	
12	ETE	Wait until the Janus scenario loads. Verify: Scenario number ________ Total number of units ________		
13	ETE	Double click the *side1* icon to bring up the scenario window.	This brings up the scenario window which allows a Janus operator to interact (game) the exercise.	

Step #	POC	Action	Event	Go/No Go
Run Scenario				
1	ETE	From the *side1* scenario window, left click ***DIS***.	DIS button highlights. Opens DIS communications.	
2	ETE	From the *side1* scenario window, left click ***START***.	First step in running a Janus scenario.	
3	ETE	Minimize the Janus scenario window (*side1*). Type ***rr*** in the Janus window, and hit ***enter***.	Ready to continue the Janus run.	
4	ETE	Type ***n*** and hit ***enter***.	No planned save.	
5	ETE	Hit ***enter*** again.	Default checkpoint frequency.	
6	ETE	Double click the Janus scenario window (*side1*).	Verifies scenario movements and a running time of day counter.	
7	ETE	Verify that loggers are logging.		

Step #	POC	Action	Event	Go/No Go
Stop Scenario				
1	ETE	From the *side1* scenario window, left click ***DIS***.	DIS button unhighlights. Closes DIS communications.	
2	ETE	From the *side1* scenario window, right click ***ADMIN***.	Brings up options menu.	
3	ETE	Left click ***EJ*** (End Janus).	Quits the scenario run.	
4	ETE	Right click 2 times.	Completely closes Janus.	
5	ETE	Left click EXIT from the HP VUE front panel.	Sign off the hp715.	

Step #	POC	Action	Event	Go/No Go
Shut Down Test				
1	ETE	Power off the c180 monitor, and shutdown CPU.		
2	ETE and N&E	Make sure that JADS N&E FTP */disk2/logfiles/__________wsmr.log* back to JADS and place the file in ***/usr/testdata2/logs/ete/DDMMYY***	Ensures data integrity. This file will be analyzed by JADS analysts.	
3	ETE	Power off the wsmr monitor.		
4	ALL	After-action review		

APPENDIX B

Joint STARS Multiservice Operational Test and Evaluation Phase 3 Measures Correlation

May 1999

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Appendix B
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APPENDIX C -- Glossary

A

Accreditation. See: distributed simulation accreditation, model/simulation accreditation.

Accuracy. The degree of exactness of a model or simulation relative to an established standard with high accuracy implying low error. [DIS]

Activity. An event that consumes time and resources and whose performance is necessary for a system to move from one event to the next. [DIS]

Advanced Distributed Simulation (ADS). A set of disparate models or simulations operating in a common synthetic environment. The ADS may be composed of three modes of simulation: live, virtual and constructive, where the latter can be seamlessly integrated within a single exercise. **See also:** live simulation; virtual simulation; constructive simulation. [DIS]

Aggregate. An activity that combines individual entities into a singular entity. **Contrast with:** disaggregate. [DIS]

B

Battlespace. The three-dimensional battlefield. [DIS]

Benchmark. (v) The activity of comparing the results of a model or simulation with an accepted representation of the process being modeled. (n) The accepted representation of the modeled process. [DIS]

Bit. The smallest unit of information in the binary system of notation. [IEEE 1278.1]

Broadcast. A transmission mode in which a single message is sent to all network destinations, i.e., one-to-all. Broadcast is a special case of multicast. **Contrast with:** multicast; unicast. [IEEE 1278.2]

C

Compatible. Two or more simulations are distributed interactive simulation (DIS) compatible if (1) they are DIS compliant, and (2) their models and data that send and interpret protocol data units (PDUs) support the realization of a common operational environment among the systems (coherent in time and space). **Contrast with:** compliant, interoperable. [DIS]

Compliant. A simulation is distributed interactive simulation (DIS) compliant if it can send or receive protocol data units (PDUs) in accordance with the Institute of Electrical and Electronics Engineers (IEEE) Standard 1278 and 1278 (working drafts). A specific statement must be made regarding the qualifications of each PDU. **Contrast with:** compatible, interoperable. [DIS]

Conceptual Model. A description of the content and internal representations which are the user's and developer's combined concepts of the exercise. It includes logic and algorithms and explicitly recognizes assumptions and limitations. [DIS]

Constructive Simulation. Models and simulations that involve simulated people operating simulated systems. **See Also:** war games; higher order model (HOM). [DIS]

Continuous Model. (l) A mathematical or computational model whose output variables change in a continuous manner; that is, in changing from one value to another, a variable can take on all intermediate values. For example, a model depicting the rate of air flow over an airplane wing. **Syn:** continuous-variable model. (2) A model of a system that behaves in a continuous manner. **Contrast with:** discrete model. [DIS]

Continuous Simulation. A simulation that uses a continuous model. [DIS]

Continuous-Variable Model. See: continuous model. [DIS]

Control Station. (1) A facility which provides the individual responsible for controlling the simulation and the capability to implement simulation control as protocol data units (PDUs) on the distributed interactive simulation (DIS) network.
Syn: simulation - management station. [DIS]

D

Data. Representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation or processing by humans or automatic means. [DIS]

Database. A collection of data organized according to a schema to serve one or more applications. [DIS]

Data Certification. The determination that data have been verified and validated. (1) Data producer certification is the determination by the data producer that data have been verified and validated against documented standards of criteria. (2) Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific modeling and simulation (M&S) usage. [DIS]

Data Logger. A device that accepts protocol data units (PDUs) from the network and stores them for later replay in the same time sequence as the PDUs were originally received. **See also:** protocol data unit (PDU). [IEEE 1278.3]

Data Validation. The documented assessment of data by subject area experts and comparison to known or best-estimate values. (1) Data producer validation is that documented assessment within stated criteria and assumptions. (2) Data user validation is that documented assessment of data as appropriate for use in an intended modeling and simulation (M&S). [DIS]

Data Verification. The use of techniques and procedures to ensure that data meet specified constraints defined by data standards and business rules. (1) Data producer verification is the use of techniques and procedures to ensure that data meet constraints defined by data standards and business rules derived from process and data modeling. (2) Data user verification is the use of techniques and procedures to ensure that data meet user specified constraints defined by data standards and business rules derived from process and data modeling and that data are transformed and formatted properly. [DIS]

Data Verification, Validation, and Certification. The process of verifying the internal consistency and correctness of data, validating that they represent real world entities appropriate for their intended purpose or an expected range of purposes, and certifying them as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user process. **See:** data validation, data verification, and data certification. [DIS]

Dead Reckoning. See: remote entity approximation.

Deaggregate. **See:** disaggregate. [DIS]

Distributed Interactive Simulation (DIS). A synthetic environment within which humans may interact through simulation(s) at multiple sites networked using compliant architecture, protocols, standards, and databases (DoDD 5000.59P)

E

Electronic Battlefield. **See:** synthetic environment. [DIS]

Entity. Any component in a system that requires explicit representation in a model. Entities possess attributes denoting specific properties. **See:** simulation entity. [DIS]

Environment. (1) The texture or detail of the domain, such as cities, farmland, sea states, etc. (2) The external objects, conditions, and processes that influence the behavior of a system (such as terrain relief, weather, day, night, terrain cultural features, etc.) [DIS]

Event. (l) An occurrence that causes a change of state in a simulation. **See also:** conditional event; time-dependent event. (2) The instant in time at which a change in some variable occurs. [DIS]

Event-Driven Simulation. **See:** event-oriented simulation. [DIS]

Event-Oriented Simulation. A simulation in which attention is focused on the occurrence of events and the times at which those events occur; for example, a simulation of a digital circuit that focuses on the time of state transition. **Syn:** event-driven simulation; event-sequenced simulation. [DIS]

Event-Sequenced Simulation. **See:** event-oriented simulation. [DIS]

Exercise. (1) One or more sessions with a common objective and accreditation. (2) The total process of designing, assembling, testing, conducting, evaluating, and reporting on an activity. **See:** simulation exercise. **Syn:** experiment, demonstration. [DIS, IEEE 1278.3]

F

Fidelity. (1) The similarity, both physical and functional, between the simulation and that which it simulates. (2) A measure of the realism of a simulation. (3) The degree to which the representation within a simulation is similar to a real-world object, feature, or condition in a measurable or perceivable manner. **See also:** model/simulation validation. [DIS, IEEE 1278.1]

Field. (1) A series of contiguous bits, treated as an instance of a particular data type, that may be part of a higher level data structure. (2) An external operating area for actual vehicles or live entities. **See:** field instrumentation. [DIS, IEEE 1278.1]

G

Graphical Model. A symbolic model whose properties are expressed in diagrams. For example, a decision tree used to express a complex procedure. **Contrast with:** mathematical model; narrative model; software model; tabular model. [DIS]

Ground Truth. The actual facts of a situation without errors introduced by sensors or human perception and judgment. [DIS]

H

Human-in-the-Loop Model. See: interactive model.

Human-Machine Simulation. A simulation carried out by both human participants and computers, typically with the human participants asked to make decisions and a computer performing processing based on those decisions. [DIS]

I

Interactive Model. A model that requires human participation. **Syn:** human-in-the-loop model. [DIS]

Interoperable. Two or more simulations are distributed interactive simulation (DIS) interoperable for a given exercise if they are DIS compliant, DIS compatible, and their performance characteristics support a fair fight to the fidelity required for the exercise. **Contrast with:** compatible, compliant. [DIS]

Interoperability. (1) The ability of a set of simulation entities to interact with an acceptable degree of fidelity. The acceptability of a model is determined by the user for the specific purpose of the exercise, test, or analysis. (2) The ability of a set of distributed interactive simulation applications to interact through the exchange of protocol data units. [DIS]

L

Live Entity. A perceptible object that can appear in the virtual battlespace but is unaware and nonresponsive (either by intent, lack of capability or circumstance) to the actions of virtual entities. **See also:** field instrumentation. **Contrast with:** live instrumented entity. [DIS]

Live Instrumented Entity. A physical entity that is in the real world and can be represented in the distributed interactive simulation (DIS) virtual battlespace which can be manned or unmanned. The live instrumented entity has internal and/or external field instrumentation (FI) devices/systems to record and relay the entity's surroundings, behavior, and/or reaction to events. If the FI provides a two-way link, the events that affect the live instrumented entity can be occurring in the virtual battlespace as well as the real world. **See also:** field instrumentation, live entity. [DIS]

Local Area Network (LAN). A class of data network which provides high data rate interconnection between network nodes in close physical proximity. [IEEE 1278.3]

M

Measure of Performance (MOP). Measure of how the system/individual performs its functions in a given environment (e.g., number of targets detected, reaction time, number of targets nominated, susceptibility of deception, task completion time). It is closely related to inherent parameters (physical and structural) but measures attributes of system behavior. **See also:** measures of effectiveness (MOE). [IEE 1278.3]

Model. (l) An approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system.

Note: Models may have other models as components. (2) To serve as a model as in (1). (3) To develop or use a model as in (1). (4) A mathematical or otherwise logical representation of a system or a system's behavior over time. [DIS]

Model/Simulation Accreditation. The official certification that a model or simulation is acceptable for use for a specific purpose. **See also:** distributed simulation accreditation. **Contrast with:** model/simulation validation, model/simulation verification. [DoDD 5000.59]

Model/Simulation Validation. The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended use(s) of the model. **See also:** distributed simulation validation, fidelity. **Contrast with:** model simulation accreditation, model simulation verification. [DoDD 5000.59]

Model/Simulation Verification. The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. **See also:** distributed simulation verification. **Contrast with:** model simulation accreditation, model simulation validation. [DoDD 5000.59]

N

Network Filter. A system to selectively accept or reject data received from the network. [DIS]

Network Node. A specific network address. **See:** node. **Contrast with:** processing node. [DIS]

Node. A general term denoting either a switching element in a network or a host computer attached to a network. **See:** processing node; network node. [IEEE 1278.1, IEEE 1278.2]

O

Operational Environment. A composite of the conditions, circumstances, and influences which affect the employment of military (or other) forces and the decisions of the unit commander or person in charge. [DIS]

P

Platform. A generic term used to describe a level of representation equating to vehicles, aircraft, missiles, ships, fixed sites, etc., in the hierarchy of representation possibilities. Other representation levels include units (made up of platforms) and components or modules (which make up platforms.) [DIS]

Protocol Data Unit (PDU). A distributed interactive simulation (DIS) data message that is passed on a network between simulation applications according to a defined protocol. [IEEE 1278.1]

R

Real Time. In modeling and simulation, simulated time advances at the same rate as actual time; for example, running the simulation for one second results in the model advancing time by one second. **Contrast with:** fast time, slow time. [DIS]

Resolution. (1) The degree to which near equal results values can be discriminated. (2) The measure of the ability to delineate picture detail. [DIS]

S

Scenario. (1) Description of an exercise (initial conditions). It is part of the session database which configures the units and platforms and places them in specific locations with specific missions. (2) An initial set of conditions and time line of significant events imposed on trainees or systems to achieve exercise objectives. **See:** field exercise. [DIS, IEEE 1278.3]

SIMNET (Simulator Networking). The prototype distributed simulation upon which DIS was based. [DIS]

Simulate. To represent a system by a model that behaves or operates like the system. **See also:** emulate. [DIS]

Simulated Time. Time as represented within a simulation. **Syn:** virtual time. **See also:** fast time; real time; slow time. [DIS]

Simulation. (l) A model that behaves or operates like a given system when provided a set of controlled inputs. **Syn:** simulation model. **See also:** emulation. (2) The process of developing or using a model as in (1). (3) An implementation of a special kind of model that represents at least some key internal elements of a system and describes how those elements interact over time. [DIS]

Simulation Environment. (1) Consists of the natural physical environment surrounding the simulation entities including land, oceans, atmosphere, near-space, and cultural information. (2) All the conditions, circumstances, and influences surrounding and affecting simulation entities including those stated in (1). [DIS]

Simulation Exercise. An exercise that consists of one or more interacting simulation applications. Simulations participating in the same simulation exercise share a common identifying number called the exercise identifier. These simulations also utilize correlated representations of the synthetic environment in which they operate. **See:** live simulation. [IEEE 1278.1, IEEE 1278.2]

Simulation Fidelity. Refers to the degree of similarity between the simulated situation and the operational situation. [IEEE 1278.3]

Simulation Time. (1) A simulation's internal representation of time. Simulation time may accumulate faster, slower, or at the same pace as real time. (2) The reference time (e.g., universal coordinated time) within a simulation exercise. This time is established ahead of time by the simulation management function and is common to all participants in a particular exercise. [DIS, IEEE 1278.1]

Simulator. (1) A device, computer program, or system that performs simulation. (2) For training, a device which duplicates the essential features of a task situation and provides for direct practice. (3) For distributed interactive simulation (DIS), a physical model or simulation of a weapons system, set of weapon systems, or piece of equipment which represents some major aspects of the equipment's operation. [DIS]

Site. (1) An actual physical location at a specific geographic area, e.g., the Fort Knox Close Combat Test Bed (CCTB). (2) A node on the network used for distributed simulation such as the Defense Simulation Internet (DSI) long haul network. (3) A level of configuration authority within a DIS exercise. [DIS]

V

Validation. See: data validation, distributed simulation validation, face validation, model/simulation validation. [DIS]

Verification. See: data verification, distributed simulation verification, model/simulation verification

Verification and Validation (V&V) Proponent. The agency responsible for ensuring V&V is performed on a specific model or simulation. [DIS]

Vignette. A self-contained portion of a scenario. [DIS]

Virtual Battlespace. The illusion resulting from simulating the actual battlespace. [DIS]

W

War Game. A simulation game in which participants seek to achieve a specified military objective given pre-established resources and constraints; for example, a simulation in which participants make battlefield decisions and a computer determines the results of those decisions. **See also:** management game. **Syn:** constructive simulation; higher order model (HOM). [DIS]

Wide Area Network (WAN). A communications network of devices which are separated by substantial geographical distance. **Syn:** long haul network. [IEEE 1278.3]

APPENDIX D -- List of Acronyms

ADA	air defense artillery
ADS	advanced distributed simulation
ADT	air data terminal
AFATDS	Advanced Field Artillery Tactical Data System
AFB	Air Force base
AFOTEC	Air Force Operational Test and Evaluation Center, Kirtland AFB, New Mexico
ALQ-131	a mature self-protection jammer system; an electronic countermeasures system with reprogrammable processor developed by Georgia Technical Research Institute
AM	amplitude modulation
ANIU	air network interface unit
ARIES	Advanced Radar Imaging Emulation System
ARPA	Advanced Research Projects Agency
ASAS	All Source Analysis System
ATACMS	Army Tactical Missile System
ATWS	Advanced Technology Work Station
Bde	brigade
Bn	battalion
C4I	command, control, communications, computers and intelligence
C4ISR	command, control, communications, computers, intelligence, surveillance and reconnaissance
CAMPS	Compartmented All Source Analysis System (ASAS) Message Processing System
CBS	corps battlefield simulation
CDP	central data processor
CEP	circular error probability
CGS	common ground station
Co	company
COI	critical operational issue
CPU	central processing unit
D&SA BL	Depth and Simultaneous Attack Battle Lab
DCT	digital communications terminal
DDSA	deputy director, system assessment
DIS	distributed interactive simulation
DMAP	data management and analysis plan
DoD	Department of Defense
DT&E	developmental test and evaluation
ECCM	electronic counter-countermeasures
ESPDU	entity state protocol data unit
ETE	End-to-End Test
EW	electronic warfare

FDC	fire direction center
FI	functionality and integration
FTI	fixed target indicator
GDT	ground data terminal
GHQ	general headquarters
GNIU	ground network interface unit
GPS	global positioning system
GSM	ground station module
HF	high frequency
HLA	high level architecture
HOM	high order model
HQ	headquarters
hrs	hours
ID	infantry division; identification
IEEE	Institute of Electrical and Electronics Engineers
JADS	Joint Advanced Distributed Simulation, Albuquerque, New Mexico
Janus	interactive, computer-based simulation of combat operations
Joint STARS	Joint Surveillance Target Attack Radar System
JPO	joint program office
JT&E	joint test and evaluation
JTF	joint test force
km	kilometers
LAN	local area network
LFP	Live Fly Phase
LGSM	light ground station module
LSP	Linked Simulators Phase
M&IS	management and integration software
M&S	modeling and simulation
MB	megabyte
Mbps	megabits per second
MGSM	medium ground station module
MI	military intelligence
mm	millimeter
MOE	measure of effectiveness
MOP	measure of performance
MOT&E	multiservice operational test and evaluation
ms	millisecond
MTI	moving target indicator
N&E	network and engineering
NC	network coordinator
NETVisualizer™	software that displays real-time bandwidth use in a rolling bar graph format for quick visual reference
NIU	network interface unit
NTP	network time protocol
O&C	operations and control

OSD	Office of the Secretary of Defense
OT&E	operational test and evaluation
OWS	operator workstation
PDU	protocol data unit
PM	program manager
PME	primary mission equipment
POC	point of contact
PTP	program test plan
PVD	plan view display
RCL	radar components laboratory
RPSI	radar processor simulator and integrator
RSR	radar service request
RWS	remote workstation
SAIC	Science Applications International Corporation
SAR	synthetic aperture radar
SATCOM	satellite communications
SCDL	surveillance control data link
SE	synthetic environment
sec	second
SGI	Silicon Graphics, Inc.
SIT	System Integration Test
SM&C	system management and control
SMO	system management office
Spectrum™	an instrumentation suite used to measure bandwidth utilization
STARS	surveillance target attack radar system
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command
SUT	system under test
SWA	Southwest Asia
T&E	test and evaluation
T-1	digital carrier used to transmit a formatted digital signal at 1.544 megabits per second
TAC	target analysis cell
TAFSM	Tactical Army Fire Support Model
TCAC	Test Control and Analysis Center, Albuquerque, New Mexico
TEXCOM	U.S. Army Test and Experimentation Command
TRAC	U.S. Army Training and Doctrine Command (TRADOC) Analysis Center
TRADOC	U.S. Army Training and Doctrine Command
UAV	unmanned aerial vehicle
UDP	user datagram protocol
UHF	ultra high frequency
V&V	verification and validation
VDP	VSTARS data packet
VHF	very high frequency
VSTARS	Virtual Surveillance Target Attack Radar System
VV&A	verification, validation, and accreditation

VV&C	verification, validation and certification
WAN	wide area network
WSMR	White Sands Missile Range
XPATCHES	E-8C synthetic aperture radar simulation developed by Wright Laboratory, Dayton, Ohio, and Loral Defense Systems, Goodyear, Arizona